

ORDNANCE MANUAL

FOR

THE USE OF THE OFFICERS

OF THE

UNITED STATES ARMY.

Washington :

J. AND G. S. GIDEON, PRINTERS.

1841.

Lc. mil.

Ordnance

80 u

UNITED STATES ARMY

Washington

J. M. W. H. Smith, Printer

1891

ORDNANCE MANUAL

FOR

THE USE OF THE OFFICERS

February 24th, 1841.

The accompanying Ordinance Manual, containing information highly useful in the military service is respectfully submitted to the Secretary of War with a recommendation that it be printed, for the use of the Officers of the Ordnance Department and of the Army generally.

GEO. BOMFORD,

UNITED STATES ARMY.

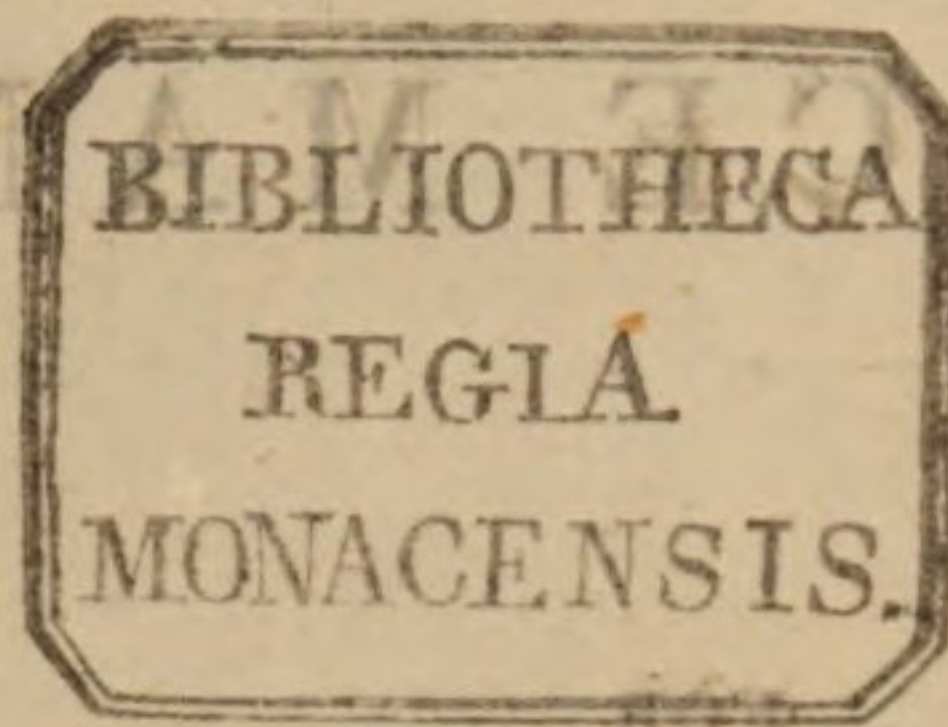
APPROVED:

J. R. POINSETT.

Washington:

J. AND G. S. GIDEON, PRINTERS.

1841.



THE USE OF THE OFFICERS

OF THE

UNITED STATES ARMY.

Washington:

J. and W. G. Thompson, Printers.

1891.

ORDNANCE OFFICE,

February 24th, 1841.

The accompanying Ordnance Manual, containing information highly useful in the military service, is respectfully submitted to the Secretary of War, with a recommendation that it be printed, for the use of the Officers of the Ordnance Department and of the Army generally.

GEO. BOMFORD,

Col. of Ordnance.

APPROVED:

J. R. POINSETT.

APPROVED:
J. R. POINSETT.

Col. of Ordnance.
GEO. BOMFORD,

ment and of the Army generally.
be printed, for the use of the Officers of the Ordnance Depart-
ment to the Secretary of War, with a recommendation that it
tion highly useful in the military service, is respectfully sub-
The accompanying Ordnance Manual, containing informa-
February 24th, 1841.
ORDNANCE OFFICE,

PREFACE.

The following work, compiled by the Ordnance Board, is designed to embody, in a convenient form for reference, many of the practical memoranda and details of information required in the discharge of the various duties of an Ordnance Officer.

The numerous changes in the *materiel* which have been made of late years and which are still in progress, make it impossible to present this information in as complete and satisfactory a manner as could be desired; but it is thought that a useful step towards perfecting our armament will be made by rendering accessible to all officers a knowledge of the details as now established.

In the arrangement of subjects and in the manner of treating them, the French "Aide Mémoire a l'usage des Officiers d'artillerie," (1836,) has been followed, as far as the plan of this work admitted, and it will be seen that extracts have been made from such parts of that admirable manual as are applicable to our service; a sufficient reason for this will be found in the fact that our systems, both of artillery and small arms, are based in a great measure on the French models, and in many important particulars are copied closely from them. The present work being designed chiefly for the use of those charged with the fabrication and care of the *materiel*, leaves untouched nearly all that relates to the personal service of artillery, either in the field or in garrison. The adoption of this plan has

admitted many useful tables and other practical data which are not found united, in the same form, in any other work.

Aware of the imperfections of this Manual, (in a great measure unavoidable,) the compilers present it as a first essay to supply a want severely felt by officers of the Ordnance Department, and as a basis for future systematic improvements in their branch of the service; with this view it is earnestly requested that all officers of the Army, and those of the Ordnance Department especially, will avail themselves of every opportunity to verify the details and add to the information here given, and that they will communicate to the Colonel of Ordnance any corrections or amendments which it may appear advisable to make in a future edition of the work.

GEO. TALCOTT,

Lt. Col. Ordnance.

R. L. BAKER,

Major of Ordnance.

JOHN SYMINGTON,

Capt. Ordnance.

A. MORDECAI,

Capt. Ordnance.

BENJ. HUGER,

Capt. Ordnance.

ORDNANCE BOARD.

February, 1841.

TABLE OF CONTENTS.

CHAP. I. CANNON.

	Page.
Kinds and calibres - - -	1
<i>Nomenclature.</i>	
Guns - - -	1
Howitzers - - -	2
Mortars - - -	3
<i>Dimensions and Weights.</i>	
Guns - - -	4
Howitzers - - -	5
Mortars - - -	6
<i>Materials for Cannon.</i>	
Bronze - - -	7
Cast iron - - -	8
<i>Inspection and Proof of Cannon.</i>	
Instruments - - -	8
Inspection of iron cannon - - -	10
Inspection of brass cannon - - -	13
Proof of iron cannon - - -	14
Proof of brass cannon - - -	16
Marking cannon - - -	16
Injuries in service - - -	17
Spiking—Preservation - - -	18
Cannon of foreign countries - - -	19

CHAP. II. SHOT AND SHELLS.

<i>Nomenclature, Dimensions, Weights.</i>	
Shot and shells - - -	25
Carcasses—Spherical case—Grape shot - - -	26
Canister shot—Grenades—Leaden balls - - -	27
Diameters of cast iron balls - - -	28
Rules for weight of balls, &c. - - -	28
<i>Inspection of shot and shells</i> - - -	29
<i>Preservation and Piling of balls</i> - - -	30
Table of piles of balls - - -	32

CHAP. III. CARRIAGES.

<i>Nomenclature.</i>	
Field gun carriage - - -	33
Wheel—Limber - - -	35
Ammunition chest - - -	36
Caisson - - -	37
Forge - - -	38
Battery wagon - - -	40
Mountain howitzer carriage - - -	42
Siege gun carriage - - -	43
Casemate carriage - - -	46
Barbette carriage - - -	47
Mortar carriage - - -	49
Mortar beds - - -	50
Gins.—Siege and garrison - - -	50
Casemate—Rampart - - -	51
<i>Dimensions and Weights.</i>	
Field and siege gun carriages - - -	52
Other field carriages—Gins - - -	53
Garrison and sea coast carriages - - -	54

CHAP. III.—Continued.

	Page.
<i>Bills of Timber.</i>	
Field carriages - - -	56
Siege carriages - - -	57
Garrison and sea coast carriages—Gins - - -	58
<i>Bills of Iron.</i>	
12-Pdr. field gun carriage - - -	59
Limber - - -	60
Light 6-pdr. carriage - - -	61
Mountain howitzer carriage - - -	62
Battery wagon - - -	63
24-Pdr. siege carriage - - -	64
Casemate gin - - -	66
Casemate carriage - - -	67
Barbette carriage - - -	68

CHAP. IV. IMPLEMENTS AND EQUIPMENTS.

<i>Nomenclature, Dimensions, Weights.</i>	
Rammer heads—Sponge heads - - -	69
Sponges—Sponge covers - - -	70
Ladle heads—Ladles - - -	71
Worms—Staves - - -	72
Handspikes - - -	74
Linstock—Portfire stock—Pass box—	
Budge barrel—Havresack - - -	75
Portfire case—Tube pouch - - -	76
Priming horn—Priming wire—Gunner's	
gimlet—Vent punch—Thumbstall—	
Portfire cutter—Tangent scale - - -	76
Cannon locks—Fuze setter—Fuze mal-	
let—Fuze saw—Fuze rasp—Fuze	
auger—Fuze gimlet—Shell plug screw	
—Fuze extractor - - -	77
Gunner's quadrant—Mortar implements	
—Elevating machine—Vent covers - - -	78
Tarpaulins—Shell hooks—Tow hook—	
Funnel—Powder measure—Prolonge	
—Sponge bucket - - -	79
Tar bucket—Shovel—Pickaxe—Felling	
axe—Bill hook—Drag rope—Men's	
harness - - -	80
Arrangement in store - - -	81

CHAP. V. ARTILLERY HARNESS.

<i>Materials, &c.</i> - - -	83
<i>Nomenclature.</i>	
Halter—Curb bridle - - -	84
Snaffle bridle—Driver's saddle - - -	85
Valise saddle—Valise—Whip—Leg	
guard - - -	86
Collar—Hames—Traces - - -	87
Side pipes—Crupper - - -	88
Breeching - - -	89
<i>Dimensions of leather parts</i> - - -	90
<i>Harness for each horse</i> - - -	91
<i>Preservation in store</i> - - -	91

TABLE OF CONTENTS.

CHAP. VI. SMALL ARMS.

	Page.
<i>Nomenclature.</i>	
Musket, model of 1840 - - -	93
Musket, model of 1822 - - -	95
Musketoons—Pistol - - -	95
Common rifle—Hall's rifle - - -	96
Hall's carbine - - -	97
<i>Dimensions and Weights</i> - - -	98
<i>Inspection of Small Arms</i> - - -	99
Verifying gauges - - -	100
Inspection and proof of barrels - - -	102
Locks - - -	104
Mountings—Ramrods—Bayonets - - -	106
Stocks - - -	107
Appendages—Finished arms - - -	108
Inspection of Hall's arms - - -	110
General directions - - -	113
<i>Browning arms</i> - - -	114
<i>Packing arms—Musket box</i> - - -	115
<i>Packing arms in straw</i> - - -	116
<i>Preservation in store</i> - - -	117
<i>Care of arms in service</i> - - -	119
<i>Cleaning arms</i> - - -	121
<i>Care of Hall's arms</i> - - -	122
<i>Inspection of arms in service</i> - - -	123
<i>Repair of arms</i> - - -	125
List of armorer's tools - - -	127
Spare parts required for repairs - - -	128
<i>Durability of musket barrels</i> - - -	129

SWORDS AND SABRES.

<i>Nomenclature.</i>	
Cavalry sabre—Artillery sabre - - -	131
Artillery sword—Infantry sword - - -	132
<i>Dimensions and weights</i> - - -	133
<i>Proof and Inspection</i> - - -	133
<i>Packing—Cleaning</i> - - -	134

CHAP. VII. ACCOUTREMENTS.

<i>Nomenclature, Dimensions.</i>	
Cavalry accoutrements - - -	135
Horse equipments for Dragoons - - -	136
Infantry accoutrements - - -	140
Artillery accoutrements - - -	140
Rifle accoutrements - - -	141
<i>Materials for accoutrements</i> - - -	141
<i>Weight of accoutrements</i> - - -	144

CHAP. VIII. GUNPOWDER.

<i>Materials.</i>	
Saltpetre - - -	145
Charcoal—Sulphur - - -	148
<i>Manufacture.</i>	
Proportions—Fabrication - - -	149
<i>Density and Specific gravity</i> - - -	152
<i>Packing</i> - - -	154
<i>Inspection and Proof</i> - - -	155
<i>Analysis</i> - - -	158
<i>Restoring—Preservation, &c.</i> - - -	159
<i>Lightning Rods</i> - - -	161

CHAP. IX. AMMUNITION AND FIREWORKS.

	Page.
<i>Laboratory.</i>	
Buildings—Fixtures and furniture - - -	165
Furnaces - - -	166
Tools and implements - - -	167
Powder measures - - -	170
Precautions against accidents - - -	171
<i>Materials.</i>	
Saltpetre—Charcoal - - -	171
Sulphur—Gunpowder—Lead - - -	172
Various metals - - -	173
Laboratory paper - - -	174
Paste—Glue - - -	175
Miscellaneous materials - - -	176
<i>Flints</i> - - -	177
<i>Cartridges for small arms</i> - - -	178
<i>Making balls</i> - - -	179
<i>Making cartridges</i> - - -	180
<i>Bundling—Packing</i> - - -	183
<i>Ammunition for Cannon.</i>	
Charges for field service - - -	184
Cartridge bags - - -	185
Cartridge blocks - - -	186
Sabots—Straps - - -	187
Strapping shot and shells - - -	188
Cylinders and caps - - -	189
Fixing ammunition - - -	189
Packing ammunition - - -	191
Strapping shells for sea coast howitzers - - -	193
Canisters - - -	193
Grape - - -	195
Cartridges for siege and garrison service - - -	197
Wads - - -	200
Filling shells - - -	201
Spherical case shot - - -	202
<i>Military Fireworks.</i>	
Slow match - - -	203
Quick match - - -	204
Priming tubes - - -	205
Portfires - - -	206
Fuzes - - -	208
Percussion primers - - -	210
<i>Fireworks for Signals, Lights, &c.</i>	
Signal rockets - - -	212
Fire stone - - -	218
Valenciennes composition—Carcasses - - -	219
Fire balls - - -	220
Light balls—Tarred links—Pitched fascines—Torches - - -	222
Kit—Incendiary match—Blue lights - - -	223
<i>Storage and Preservation of Ammunition, &c.</i> - - -	223
<i>Breaking up unserviceable stores</i> - - -	225
Unloading shells - - -	226

CHAP. X. PACKING AMMUNITION CHESTS—
LOADING ARTILLERY CARRIAGES.

Contents of ammunition chests—Arrangement and manner of packing - - -	227
Unpacking ammunition chests - - -	230
Forge for repairs - - -	230
Shoeing forge - - -	232

TABLE OF CONTENTS.

ix.

CHAP. X.—Continued.

Battery wagon for stores	-	-	Page.
Wagon for harness	-	-	232
	-	-	236

CHAP. XI. TRAINS OF ARTILLERY—ARMAMENT OF FORTIFICATIONS.

<i>Field Train.</i>			
Ordnance—Ammunition	-	-	237
Ammunition for small arms	-	-	238
Composition of field batteries—Implements and equipments	-	-	239
Horses—Harness	-	-	240
<i>Siege Train.</i>			
Cannon—Carriages	-	-	240
Horses—Ammunition	-	-	241
Implements and equipments	-	-	242
Various stores—Tools—Materials, &c.	-	-	243
<i>Armament of Fortifications.</i>			
Carriages—Ammunition	-	-	245
Small arms	-	-	246
Implements and equipments	-	-	247
Spare parts of carriages—Various stores—Tools, &c.	-	-	248

CHAP. XII. MATERIALS.

<i>Timber.</i>			
Kinds of wood	-	-	251
Selection of trees—Felling timber	-	-	252
Defects of timber trees—Seasoning and preserving timber	-	-	253
Measuring timber	-	-	254
<i>Iron.</i>			
Making pig iron	-	-	255
Malleable iron	-	-	256
Cast iron	-	-	259
Steel	-	-	260
Sheet iron—Tin	-	-	263
Files and rasps	-	-	264
Storage of metals	-	-	265
<i>Coal.</i>			
Charcoal	-	-	266
Pit coal—Coke	-	-	267
Ropes	-	-	268
Tar—Pitch—Turpentine	-	-	269

CHAP. XIII. PAINTS, LACKERS, ETC.

<i>Composition and Preparation.</i>			
Boiled oil—Dryings—Putty—White paint	-	-	271
Lead color—Grey—Cream color—Black	-	-	272
Olive	-	-	273
Quantity of paint required for a carriage	-	-	273
Paint for tarpaulins	-	-	273
Lackers for iron ordnance	-	-	274
Lacker for small arms and for water proof paper	-	-	275
Lacker for bright iron work	-	-	275
Varnish for scabbards, &c.	-	-	275
Japan varnish	-	-	276
Grease for carriage wheels	-	-	276

CHAP. XIV. MECHANICAL MANŒUVRES.

<i>Field Artillery.</i>		Page.
To change a wheel—To dismount a piece—To mount a piece—To transport a piece with the limber	-	277
<i>Siege and Garrison Artillery.</i>		
Implements—Ropes	-	278
Preliminary manœuvres	-	279
To change a piece to and from the travelling position—To change a wheel—To mount a piece	-	280
To dismount a piece—To change a carriage	-	281
To transport a piece with a sling cart—To move a piece by hand in the trenches	-	282
To extract a piece mired—To mount and dismount a barbette carriage and gun on its chassis	-	283
To mount a casemate gun	-	284
<i>Manœuvres of the Gin.</i>		
To put the gin together	-	284
To carry, to set up, to equip the gin	-	285
To sling a piece	-	286
To work the gin	-	287
To use the gin as a derrick	-	287

CHAP. XV. ARTILLERY PRACTICE—PENETRATION OF SHOT.

Practice with 12-pdr. field howitzer	-	289
Practice with 8-in. sea coast howitzer	-	290
Firing hot shot	-	290
Expansion of shot by heat	-	292
<i>Penetration of shot and shells—Experiments at Metz.</i>		
Penetration of shot in masonry	-	293
Penetration in oak wood	-	294
Penetration in earth	-	295
Penetration of shells	-	296
Penetration in fascines, wool, &c.—Effects of shot on cast iron	-	296
<i>Experiments at Fort Monroe.</i>		
Penetration in masonry	-	297
<i>Experiments at New York.</i>		
Penetration in oak	-	297
Penetration of leaden balls	-	298

CHAP. XVI. MISCELLANEOUS INFORMATION.

<i>Weights and Measures.</i>		
Measures of length	-	299
Reducing foreign long measures to United States measures	-	300
Superficial measures—Solid measures—Measures of capacity	-	302
Weights	-	304
Measures of value	-	305
Dimensions of Drawing Paper	-	306
<i>Physical Data.</i>		
Working power of men and horses	-	306
Properties of metals	-	307

CHAP. XVI.—Continued.

	Page.
Thermometers - - -	308
Conducting power of different substances—Specific heat—Expansion by heat	309
Melting points of solids—Freezing points of solids—Boiling points of liquids	310
Freezing mixtures—Heating power of combustibles—Elastic force of steam	311
Velocity of sound - - -	312
Velocity and force of the wind - - -	312
Force of gravity - - -	312
Measurement of heights by means of the barometer - - -	313
Annual fall of rain—Limits of vegetation—Perpetual snow - - -	313
Variation and Dip of the magnetic needle - - -	313
<i>Mathematical Formulae and Data.</i>	
Mensuration - - -	314

CHAP. XVI.—Continued.

	Page.
Centre of gravity - - -	317
Arithmetical Progression - - -	318
Geometrical Progression - - -	318
Plane Trigonometry - - -	318
Table of natural sines and tangents - - -	320
Table of the areas and circumferences of circles - - -	322
Table of the areas of circular segments	330
Table of Squares, Cubes and Roots - - -	331
<i>Weight of Materials.</i>	
Table of specific gravities - - -	351
Weight of round iron - - -	352
Weight of flat and square iron - - -	353
Weight of iron plate - - -	354
Weights of various metals - - -	355
Weight of cast iron pipes - - -	356
List of books of reference. - - -	357

LIST OF PLATES.

- PLATE 1 } Cannon.
 " 2 }
 " 3—Field Gun Carriage.
 " 4—Caisson and Limber.
 " 5—Travelling Forge.
 " 6—Battery Wagon.
 " 7—Siege Gun Carriage and Limber.
 " 8—Casemate Carriage.
 " 9—Barbette Carriage.
 " 10—Harness.
 " 11—Small Arms.
 " 12—Packing Boxes for small arms.
 " 13—Fixed Ammunition.
 " 14—Ammunition Chests.
 " 15—Knots used in Mechanical Manœuvres.

ERRATA AND ALTERATIONS.

Page 5—9th line of table, 2d column,	-	-	for 101	-	read 109.
" 9—Line 4	-	-	" 0.1	-	" 1.
" 54—4th line from the bottom, three last columns	-	-	" 120	-	" 120.33.
" 58—1st line of the table of figures in the three columns of "length"	-	-	" 69	-	" 138.
" 58—32 pdr. barbette chassis, length of front, middle and rear transoms	-	-	" 54	-	" 57.
" 58—32 pdr. barbette chassis, thickness of rear transom	-	-	" 8	-	" 9.
" 67—11th line of table of figures, 2d column	-	-	" 1.125	-	" 0.125.
" 86—4th and 5th lines from the bottom	-	-	" $3\frac{1}{4}$	-	" $\frac{3}{4}$.
" 115—6th line from the bottom	-	-	" $7\frac{1}{8}$	-	" $\frac{7}{8}$.
" 131—Nomenclature of hilt	-	-	" beed	-	" bead.
" 135—Description of sabre belt, 4th and 5th lines	-	-	" $\frac{1}{8}$	-	" $1\frac{1}{8}$.
" 136—Head of the page	-	-	" SMALL ARMS.	"	ACCOUTREMENTS.
" 166—Do. do.	-	-	" XI	-	" IX.
" 173—12th line	-	-	" See page 8	"	See page 7.
" 189—2nd line from the bottom	-	-	" See page 115	"	See page 170.
" 300—Last line, 4th column of table	-	-	" 17.7265	-	" 11.7265.
" 322—11th line from the bottom, 3d column	-	-	" 16.67	-	" 17.67.
" 323—7th line, 3d column	-	-	" 43.29	-	" 43.19.
" 323—18th line from the bottom, last column	-	-	" 71.75	-	" 71.47.
" 325—13th line from the bottom, 2d column	-	-	" 1334.5	-	" 1344.5.
" 326—3d line, 2d column	-	-	" 1905.8	-	" 1905.0.
" 327—9th line from the bottom, 5th column	-	-	" 4067.3	-	" 4057.3.
" 329—16th line 5th column	-	-	" 6776.4	-	" 6774.6.

NOMENCLATURE.

Field guns.—Plate I.

FIGURE.—The base of the gun is a plane perpendicular to the axis of the barrel, and is divided into four equal parts of circles, the radius of which

ORDNANCE MANUAL.

CHAPTER FIRST.

CANNON.

Cannon, for the land service, are of the following kinds and calibres, viz :

- | | |
|--|--|
| FOR FIELD SERVICE. | { 6 pounder and 12 pounder guns.
12 pounder and 24 pounder howitzers. |
| FOR MOUNTAIN SERVICE, | 12 pounder mountain howitzer. |
| FOR SIEGE AND GARRISON SERVICE. | { 12 pounder, 18 pounder, and 24 pounder guns.
8 inch siege howitzer.
8 inch and 10 inch mortars, (light.)
16 inch stone mortar.
24 pounder Coehorn mortar. |
| FOR SEA COAST SERVICE. | { 24 pounder, 32 pounder, and 42 pounder guns.
8 inch and 10 inch sea coast howitzers.
24 pounder carronade, or howitzer.
10 inch and 13 inch mortars, (heavy.) |
| FOR PROVING POWDER, | 24 pounder mortar eprouvette. |

Since 1835, cannon for field service have been made of bronze ; the mountain howitzer, the stone mortar, and the Coehorn mortar, are also of bronze ; all other cannon are of iron.

Cannon for field service have also been made of iron ; and cannon, of several patterns, both for field and garrison use, are to be found at the arsenals, and in service.

The following nomenclature and tables of dimensions refer to the patterns last adopted, unless otherwise stated.

NOMENCLATURE.

Field guns.—Plate 1.

PARTS.—The *bore* ; the *bottom* of the bore is a plane perpendicular to the axis of the bore, united with the sides by quadrants of circles, the radius of which

is $\frac{1}{4}$ of the diameter of the bore; the *muzzle*; the *face*; the *muzzle mouldings*, consisting of the *lip* and the *fillet*; the *swell* of the muzzle; the *neck*; the *astragal and fillets*; the *chase*; the *reinforce*; the *breech*; the *base ring*; the *cascable*, (consisting of the *base of the breech*, the *fillet*, the *neck*, and the *knob*;) the *trunnions*; the *rimbases*; the *handles*, (for bronze 12 pounders only;) the *vent piece*, (for bronze guns;) the *vent*.

Siege and garrison guns, (pattern of 1840.)—Plate 1.

The parts are the same as for field guns, omitting the *handles* and the *vent piece*, adding the *lock piece*, and substituting a *chase ring* for the *astragal and fillets*.

Sea coast guns, (32 pounder and 42 pounder, pattern of 1840.)—Plate 1.

The same as siege and garrison guns, except that there are *two reinforces*, and that the muzzle mouldings consist of two *convex quarter rounds*.

The 42 pounder of the pattern of 1831, and the 32 pounder of the pattern of 1829, have no *chase ring* or *astragal*, and the muzzle mouldings are the same as for field guns.

The 24 pounder of 1819 has no *lock piece*, *chase ring*, or *astragal*; and the muzzle moulding consists of a *fillet* only.

Field howitzers.—Plate 1.

The *bore*, (embracing all the part bored out, viz: the *cylinder*; the *slope*, or conical *junction* of the cylinder and chamber; the *chamber*;) the *muzzle*; the *face*; the *muzzle fillet*; the *muzzle band*; the *neck*; the *chase ring*; the *chase*; the *reinforce*; the *recess*, (around the chamber of 24 pounder bronze howitzer;) the *breech*; the *base ring*; the *cascable*, (as in guns;) the *trunnions*; the *rimbases*; the *handles*, (for 24 pounder bronze howitzer;) the *vent piece*, (for bronze howitzers;) the *vent*.

Mountain howitzer.—Plate 1.

The *bore*, (as in field howitzers;) the *muzzle*; the *face*; the *muzzle band*; the *body*; the *recess*; the *base ring*; the *cascable*, (consisting of the *base of the breech*, the *neck*, and the *knob*;) the *trunnions*; the *rimbases*; the *vent piece*; the *vent*.

Siege howitzer.—Plate 2.

The *bore*, consisting of the *cylinder* and the *chamber*, with a *spherical junction*; the *muzzle*; the *face*; the *muzzle fillet*; the *muzzle band*; the *chase*;

the *reinforce*; the *recess*; the *base ring*; the *casable*, (as for guns;) the *trunnions*; the *rimbases*; the *lock piece*; the *vent*.

Sea coast howitzer.—Plate 2.

Parts the same as in sea coast guns, pattern of 1840, adding the *chamber* and its *conical junction* with the bore and the *first reinforce ring*.

13 inch and 10 inch mortars, (heavy,) 1840.—Plate 2.

The *bore*, consisting of the *cylinder* and the *conical chamber*, with their *spherical junction*; the *muzzle*; the *face*; the *muzzle band*; the *chase*; the *reinforce*; the *breech*; the *trunnions*; the *trunnion reinforces*; the *vent*; the *pan*; the *ear*, for a *clevis and bolt*.

The old pattern 10 inch mortar has a *cylindrical chamber*; the parts are the same as in the new pattern, adding *rimbases*, and omitting the *ear*.

10 inch and 8 inch mortars, (light,) 1840.—Plate 2.

The *bore*, consisting of the *cylinder* and the *chamber*, (Gomer;) the *muzzle*; the *face*; the *muzzle band*; the *body*; the *base ring*; the *breech*; the *trunnions*; the *trunnion reinforces*; the *vent*; the *pan*.

Stone mortar.—Plate 2.

The *bore*, (as in heavy sea coast mortars;) *muzzle*; *face*; *muzzle fillet*; *muzzle band*; *chase*; *reinforce ring*; *breech*; *vent piece*; *vent*; *trunnions*; *rimbases*; *handle*.

Coehorn mortar.—Plate 2.

Parts the same as for the heavy mortars, adding the *muzzle fillet* and *vent piece*, (copper,) and omitting the *ear*.

Mortar eprouvette.—Plate 2.

The *bore*, consisting of the *cylinder*, with a *hemispherical bottom*, and a *cylindrical chamber*, with a *hemispherical bottom*; the *muzzle*; the *face*; the *muzzle band*; the *chase*; the *reinforce*; the *breech*; the *sole*; the *vent*; the *pan*.

The *BED PLATE*; the *seat*; the *bolt holes*.

PRINCIPAL DIMENSIONS AND WEIGHTS OF GUNS.

	Model of	IRON.										BRONZE.		
		SEA COAST.					Sea coast and Garrison.					SIEGE AND GARRISON.		FIELD.
		1831.	1829.	1819.	1840.	1840.	1840.	1840.	1840.	1840.	1840.	1840.	1840.	
		42	32	24	42	32		24	18	12		12	6	
Diameter of the bore	-	Inches. 7.018	Inches. 6.41	Inches. 5.823	Inches. 7.	Inches. 6.4	Inches. 5.82	Inches. 5.3	Inches. 4.62	Inches. 4.62	Inch. 3.67	Inches. 4.62	Inches. 3.67	
True windage	-	0.188	0.161	0.143	0.17	0.16	0.14	0.13	0.10	0.10	0.09	0.10	0.09	
Length of bore	-	109.	107.59	108.17	110.	107.6	108.	109.	103.4	103.4	74.	74.	57.5	
Ditto, -	-	15.53	16.78	18.56	15.71	16.78	18.56	20.56	22.38	22.38	16.	16.	15.67	
Length from rear of base ring to face of muzzle	-	117.2	114.	114.	117.	114.	114.	114.	108.	108.	78.	78.	60.	
Length from rear of base ring to end of cascable	-	12.2	11.2	9.95	12.	11.2	10.	9.25	8.	8.	7.	7.	5.6	
Whole length of the piece	-	129.4	125.2	123.95	129.	125.2	124.	123.25	116.	116.	85.	85.	65.6	
Semi-diameter of the base ring	-	12.2	11.65	9.95	12.2	11.2	10.7	9.875	8.7	8.7	6.5	6.5	5.15	
Semi-diameter of the swell of the muzzle	-	8.25	7.50	7.35	8.4	7.7	7.793	6.935	5.932	5.932	5.17	5.17	4.125	
Distance between these two semi-diameters, (from rear of base ring)	-	114.25	111.16	112.6	115.	112.	111.	111.6	105.8	105.8	76.3	76.3	58.7	
Natural angle of sight	-	-	-	1° 19' 22"	-	-	1° 30'	1° 30'	1° 30'	1° 30'	1°	1°	1°	
Distance from rear of base ring to rear of trunnions	-	43.2	42.2	43.	43.2	42.2	43.	43.50	42.	42.	30.7	30.7	23.25	
Diameter of the base ring	-	24.4	22.3	19.9	24.4	22.4	21.4	19.75	17.4	17.4	13.	13.	10.3	
Distance between the rimbases	-	22.	20.7	18.	22.	20.7	18.	16.8	14.8	14.8	12.	12.	9.5	
Length of the trunnions	-	6.5	6.	5.	6.5	6.	5.	4.75	4.5	4.5	3.5	3.5	2.8	
Diameter of the trunnions	-	7.018	6.41	5.823	7.	6.4	5.82	5.3	4.62	4.62	4.62	4.62	3.67	
Diameter of the vent	-	0.2	0.2	0.2	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	
Weight	-	8,688	7,531	5,500	8,300	7,100	5,600	4,750	3,500	3,500	1,800	1,800	880	

Some bronze 6 pounders of 14 diameters length of bore have been made for light artillery.

PRINCIPAL DIMENSIONS AND WEIGHTS OF HOWITZERS.

	IRON.			BRONZE.		
	SEA COAST.		SIEGE.	FIELD.		MOUNTAIN.
	10 in.	8 in.	8 in.	24 pdr.	12 pdr.	12 pdr.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter of the bore	10.	8.	8.	5.82	4.62	4.62
True windage	0.15	0.15	0.15	0.14	0.10	0.10
Length of the bore, exclusive of the chamber	96.	85.5	38.5	56.25	46.25	28.16
Ditto,	9.6	10.68	4.81	9.66	10.	6.1
Diameter of the chamber	7.	6.4	4.62	4.62	3.67	3.34
Length of the chamber	9.5	7.5	8.	4.75	4.25	2.75
Length from rear of base ring to face of muzzle	112.	98.	52.	65.	53.	32.91
Length from rear of base ring to end of cascable	122.25	11.	9.5	6.2	5.6	4.3
Whole length of piece	124.25	101.	61.5	71.2	58.6	37.21
Semi-diameter of the base ring	13.25	11.10	9.125	6.	5.	3.8
Semi-diameter of the muzzle band, or swell of the muzzle	10.125	8.25	8.225	4.875	4.1	3.45
Distance between these two semi-diameters, (including the base ring and muzzle band)	109.5	96.	51.5	64.8	52.85	32.91
Natural angle of sight	-	-	1°	1°	1°	0° 37'
Distance from rear of base ring to rear of trunnions	41.	37.4	24.	27.5	23.25	15.
Diameter of base ring	26.5	22.2	18.25	12.	10.	7.6
Distance between the rimbases	25.	20.7	18.	11.5	9.5	6.9
Length of the trunnions	7.5	6.	5.	3.25	2.8	2.25
Diameter of the trunnions	8.	6.40	5.82	4.2	3.67	2.7
Diameter of the vent	0.175	0.175	0.175	0.175	0.175	0.175
Weight,	9,500	5,800	2,650	1,320	785	220

PRINCIPAL DIMENSIONS AND WEIGHTS OF MORTARS.

	IRON.			BRONZE.		IRON.
	HEAVY.		LIGHT.	Stone mortar.	Coehorn 24 pdr.	
	13 in.	10 in.				
Diameter of the bore	Inches. 13.	Inches. 10.	Inches. 8.	Inches. 16.	Inches. 5.82	Inches. 5.655
True windage	0.15	0.15	0.15	—	0.14	0.025
Length of the bore, exclusive of the chamber	26.	25.	12.	19.8	8.82	11.5
Ditto, in diameters	2.	2.5	1.5	1.24	1.51	2.
Diameter of the chamber, (at the bottom of the shell in iron mortars,)	* 9.5	* 7.15	6.08	* 5.3	3.	* 1.5
Length of the chamber	* 7.25	5.64	4.	3.	2.	* 1.5
Whole length of the mortar	13.	10.	4.	6.75	4.25	1.35
Distance from the face of the muzzle to the rear of the trunnions	53.	46.	22.5	31.55	16.32	
Distance between the rimbases	53.	46.	22.5	28.	16.32	
Length of the trunnions	36.	27.5	16.25	18.	7.5	
Diameter of the trunnions	8.5	6.5	4.	6.	2.5	
Diameter of the vent	12.	9.	6.	8.	2.75	
Weight,	11,200	5,800	925	0.175	0.175	0.15
				1,600	160	220

* In these mortars the bottom of the chamber is hemispherical; in the others, the angles are rounded with a radius of $\frac{1}{4}$ of the inferior diameter.

OF THE MATERIALS FOR CANNON.

Bronze.

Bronze for cannon, (commonly called *brass*,) consists of 90 parts of copper, and 10 of tin, allowing a variation of one part of tin, more or less. It is more fusible than copper, much less so than tin, more sonorous, harder, and less susceptible of oxidation, and much less ductile, than either of its components. Its fracture is of a yellowish color, with little lustre, a coarse grain, irregular, and often exhibiting spots of tin, which are of a whitish color. These spots indicate defects in the metal; but they seldom contain more than 25 per cent of tin. The specific gravity of bronze is about 8,766, being greater than the mean of the specific gravities of copper and tin.

Pure copper is of a red color, inclining to yellow; it has a fine metallic lustre. Its fracture exhibits a short, even, close grain, of a silky appearance; it is very ductile, and very malleable. The greater the purity of copper, the more malleable it is, and the finer the grain. Specific gravity from 8,600 to 9,000.

Pure tin is of a white color, a little darker than silver; it is malleable, and susceptible of being rolled into sheets, but it is not very ductile; it is very soft, and, when bent backwards and forwards, it gives a peculiar crackling sound, the distinctness of which is in proportion to the purity of the tin. Specific gravity, 7,290 to 7,320.

Analysis of bronze. Nitric acid dissolves the copper and converts the tin into an insoluble peroxide. Put into a small glass matrass 10 parts (say 100 grains) of bronze, in small particles, and 100 parts of very pure nitric acid, at 22° Beaumé's hydrometer, (specific gravity, 1,180;) heat it gradually to ebullition, and continue that heat until red vapors cease to come over; let it cool, and dilute the solution with 100 parts of distilled water; filter it with a double filter, the two parts of which are equal; wash the precipitate on the filter until the water that comes off no longer gives a blue color when heated with ammonia, and does not change the color of litmus paper; spread the filter on paper, and dry it perfectly in a stove or a sand bath; weigh it, adding the exterior filter to the weights, in order to ascertain the quantity of peroxide of tin which remains on the upper filter; 140 parts of peroxide give 100 parts of pure tin.

If lead is present, it will be dissolved by the acid; to detect it:—after the solution is cool, add sulphate of soda, in order to precipitate the lead in the state of an insoluble sulphate, 145 parts of which contain 100 of lead.

Cast iron.

(See chapter 12.)

Iron for making cannon must be of the best quality, selected particularly for its strength; the grain should be close, with a good lustre, the color *dark grey*; the surface of the fracture rough and irregular, having the appearance of being *torn*, as the workmen term it. If too soft, its hardness and strength may be increased by remelting it once or twice, or by mixing with it scraps of former meltings, or harder iron. When cast into cannon, the iron should appear *bright* or *mottled*, but it is impossible to give exact instructions for judging of the qualities of iron by inspection, as they vary even with the peculiar working of the furnace in which the iron is melted: some indications of the strength are furnished by analysis, and by testing the strength of a bar cast from the iron to be tried, and comparing the results of these investigations with those obtained from iron known to be of a good quality; but the most decisive test is afforded by the proof of a model gun.

INSPECTION OF CANNON.

Instruments.

1. The *cylinder-staff* is a wooden staff 1.5 inches in diameter, and 10 feet long. It is composed of two pieces, which can be taken apart or joined together at pleasure, by means of a screw. On each end of the staff is a screw, with a strong thread to attach it to the *cylinder-gauge*, *calibre-plate*, *guide-plate*, and *measuring point*. It is graduated into feet, inches, and tenths; the graduation commencing at the distance of four feet from the end of the measuring point, when it is screwed on, from which point the distances are counted.

2. The *cylinder-gauge* is a hollow cylinder of wrought iron, one calibre long, turned to the size of the minimum diameter of the bore; in the centre of each end are circular plates connected by arms with the body of the cylinder, and having holes to admit the staff. One of these holes has a thread cut in it to receive the screw on the end of the staff; the other is reamed smooth, and fits the body of the staff.

3. The *calibre-gauge* is a trapezoidal plate of iron, widening out from the size of the minimum diameter of the bore to that of the maximum, and so proportioned that the width increases 0.01 inches for each inch from the smaller end; it is used to find the diameter of the bore at the muzzle.

4. The *calibre-plate* is a circular plate of wrought iron 0.5 inches thick, of the minimum diameter of the bore, with a thread cut in the centre to screw it to the

end of the cylinder staff. A groove is cut in it to receive a narrow sliding plate which is moved by an iron rod; this rod terminates in two branches, which pass through holes in the plate; it is supported by clamps secured to the cylinder-staff by screws, and one of the branches is so made that a forward motion of 0.1 inch causes the moveable plate to rise in the groove 0.01 inch, and in that proportion up to 0.04 inch, the greatest variation of diameter allowed. The iron rod is pushed forward till the outer edge of the sliding plate coincides with the rim of the calibre-plate, when the end of the rod fixes the zero or mark of coincidence. The distance which the rod enters beyond this point shows a corresponding excess of the diameter of the bore over the minimum or diameter of the *calibre plate*.

5. The *searcher* is used to ascertain whether there are any cavities in the bore; it consists of four flat springs about 13 inches long, with sharp points, turned outwards at the end, attached to a socket on which the cylinder-staff is screwed. A ring, fixed to a handle which moves in a collar attached to the staff, serves to compress these springs, and to disengage a point when it becomes fast in a hole.

6. The *guide-plate* is a circular iron plate 0.2 inch thick, and of the minimum diameter of the bore; it has a hole in the centre, with a thread by which it is screwed to the cylinder-staff; it serves to direct the measuring point to the centre of the bottom of the bore.

7. The *measuring point* is screwed on the end of the cylinder staff, over the guide-plate, to measure the depth of the bore; it is of iron, cylindrical in shape, so far as it screws on the end of the staff, and tapering down to the diameter of 0.75 inch.

8. The *half-tompion* is a half cylinder of wood, one calibre long, fitting the bore of the gun, with a groove in the middle in which to rest the cylinder-staff when measuring the length and diameter of the bore; it serves, with the guide-plate and the calibre-plate, to keep the staff in the centre of the bore.

9. The *trunnion-gauge* is an iron ring of the diameter of the trunnions, which must pass over them and fit closely. The exterior diameter of this gauge serves to verify that of the rimbases.

10. The *trunnion-square* is a double square of wood, the distance between whose branches is the same as that between the rimbases of the gun; in the centre is a pointed sliding plate with a thumb-screw to fasten it; the lower edges of the branches, which are shod with iron, are in the same plane, parallel to the upper edge of the connecting piece, so that when the square is placed with its branches resting on the trunnions, the upper edge of the connecting piece is parallel to their axis. Each branch has also an iron plate projecting perpendicu-

larly from one side to rest on the top of the trunnions; it is used to ascertain the position of the trunnions in relation to the axis of the bore and to each other.

11. *Two wooden levels with plummets*, to fit on the base-ring and the swell of the muzzle—used to strike a bisecting line on the surface of the piece.

12. *A chalk line*.

13. *Callipers*, to measure diameters.

14. An *iron square*, divided into inches and tenths, with a stud on one side to rest the point of the callipers against.

15. A wooden *ten-foot rule*, folded in the middle, to measure exterior lengths.

16. The *vent-gauges* are two pointed pieces of steel wire, of the greatest and true diameters of the vent.

17. The *vent-searcher* is a hooked steel wire about half the diameter of the vent.

18. A *rammer-head*, shaped to the form of the bottom of the bore, and furnished with a staff, used to ascertain the interior position of the vent.

19. A *mirror*; a *wax taper*; *bees-wax*.

20. *Rammer*, *sponge*, and *priming wire*.

21. *Figure and letter stamps* to affix the required marks.

INSPECTION OF IRON CANNON.

Cannon presented for inspection and proof, are placed on skids for the convenience of turning and moving them easily. They are first examined carefully on the exterior to ascertain whether there are any flaws or cracks in the metal, whether they are finished as prescribed, and to judge, as well as practicable, of the quality of the metal. They must not be covered with paint, lacker, or any other composition. If it is ascertained that an attempt has been made to conceal any flaws or cavities by plugging, or filling them with cement, or any substance, the gun is rejected without further examination. After this preliminary examination, the inspector proceeds to verify the dimensions of the piece. The *interior of the bore* is first examined by reflecting the sun's rays into it from the mirror; or, if the sun is obscured, by a lighted wax taper or a lamp placed on the end of a rod, and inserted into the bore. The *searcher* is then introduced, and pushed slowly to the bottom of the bore and withdrawn, turning it at the same time; if one of the points hang, the position of the hole is marked on the outside of the gun by noticing its distance from the muzzle, and its position in the bore: the size and figure of the cavity are found by taking an impression of it in *wax* placed on the end of a hook. The *cylinder-gauge*, screwed on the staff, is then pushed gently to the bottom of the cylindrical part of the bore and withdrawn; it must go to the bottom, or the bore is too small. The *diameter of the*

bore at the muzzle is measured by the *calibre-gauge*. The *calibre-plate* is then pushed slowly from the muzzle to the bottom of the bore, the exact diameters of which, at points not more than one calibre apart, are measured by raising the slide by means of the rod.

The *position of the trunnions*, with regard to the axis of the bore and to each other, is next ascertained.

To verify the position of the axis of the trunnions: set the trunnion-square on the trunnions, and see that the lower edges of its branches touch them throughout their whole length; push the slide down till it touches the surface of the piece, and secure it in that position by the thumb-screw; turn the gun over, and apply the trunnion-square to the opposite side, and if, when the point of the slide touches the surface of the piece, the lower edges of the branches rest on the trunnions, the axis of the trunnions is in the same plane with the axis of the bore; if they do not touch the trunnions, their axis is above the axis of the bore by half the space between; and if the edges touch the trunnions, and the point of the slide does not touch the surface of the piece, their axis is below the axis of the bore. Place the gun with the axis of the trunnions horizontal by means of the *trunnion-square* and a *spirit-level*; apply the *plummet-levels* to the base ring and swell of the muzzle, and bring the plummets to coincide with the centre lines of the level; mark the points where the vertical lines strike the surface of the piece in both places; join these points by a *chalk line* on the surface of the piece, and this line will be the trace, on that surface, of a vertical plane through the axis of the piece, supposing the bore to be in the centre of the mass of metal. This line will be at right angles with the transverse piece of the trunnion-square, if the axis of the trunnions be at right angles with the axis of the bore; which may be further verified by measuring the distance from each trunnion to the base ring. This line also serves to verify the *position of the exterior orifice of the vent*. If the *alignment of the trunnions* be accurate, the edges of the trunnion-square will fit on them when applied to different parts of their surface: their diameter and cylindrical form, and the diameter of the rim-bases, are determined by the trunnion-gauge. To ascertain the length of the bore, screw the *guide-plate* and *measuring-point* on the cylinder-staff, and push them to the bottom of the bore; place a *half-tompion* in the muzzle, and rest the staff in its groove; apply a *straight-edge* to the face of the muzzle, and read the length of the bore on the staff. The *exterior lengths* are measured by the *rule* and *square*. The *exterior diameters* are measured with the *callipers* and *graduated square*. The *position of the interior orifice of the vent* is found from the mark made on the *rammer-head* by the *vent-gauge* inserted in the vent, while the rammer-head, coated with *wax* or *moist clay*, is held against the bottom of

the bore—two impressions are taken. The *vent* is examined with the *gauges*, and with the *vent-searcher*, to ascertain if there are any cavities in it. In *mortars*, the dimensions of the *conical chambers*, and the *form of the breech*, may be verified with *patterns* made of plate iron. After the *powder proof*, the bore is washed and wiped clean, and the bore and vent are again examined. The results of each of the measurements and examinations are noted on the inspection report against the number of the gun.

VARIATIONS ALLOWED IN THE DIMENSIONS OF IRON CANNON.

			FIELD.	GARRI- SON, & C.
			Inches.	Inches.
IN THE BORE.	{	More than the prescribed diameter -	0.03	0.04
		Less than the prescribed diameter -	.00	.00
IN EXTERIOR DI- AMETERS.	{	Where turned, more or less -	.04	.05
		Where not turned, { more -	.10	.20
		less -	.05	.05
	{	Of the bore, more or less -	.10	.20
		From rear of base ring to face of muzzle, more or less -	.10	.25
IN THE LENGTH.	{	Of the breech, including cascable, more or less -	.15	.20
		Of the base ring, more or less -	.05	.05
	{	Of the reinforce, more or less -	.10	.20
		Of the chase, including the muzzle, more or less -	.10	.15
	{	From rear of trunnions to rear of base ring, more or less -	.10	.20
IN THE POSITION OF THE AXIS OF THE TRUNNIONS.	{	above the axis of the bore -	.00	.00
		below the axis of the bore -	.20	.20
IN THE LENGTH OF THE TRUNNIONS,	{	more -	.10	.10
		less -	.05	.05
Diameter of trunnions, less -		.03	.04	
In the distance between the rimbases, less -		.05	.05	
In the same gun, no variation is allowed in the position or in the alignment of the trunnions.				
IN THE VENT.	{	Diameter, { more -	0.025	0.025
		less -	.00	.00
	{	Position of exterior orifice, more or less -	.05	.05
DEPTH OF CAVITIES.	{	Position of interior orifice, more or less -	.20	.20
		In the bore or vent -	.00	.00
	{	On the exterior surface -	.20	.25
		On the trunnions, within one inch of the rimbases -	.10	.10
	{	On the trunnions elsewhere -	.20	.25
In the <i>eprouvette</i> , no variation is allowed.				

INSPECTION OF BRASS CANNON.

Brass cannon are measured, and their dimensions recorded, as prescribed for iron cannon. *The exterior form and dimensions* are verified by the application of a *profile* cut out of sheet iron, of the exact shape of a longitudinal section of the piece. All brass cannon, except stone mortars, should be bored under size from .04 to .05 inch, and after proof reamed out to the exact calibre. When the powder proof is finished, the bore should be cleaned and examined; the vent should then be stopped with a greased wooden plug, the muzzle raised, and the gun filled with water, to which pressure shall be applied to force it into any cavities that exist; or the water shall be allowed to remain in the bore about 24 hours. *The bore* must then be sponged dry and clean, and viewed with the *mirror* or *candle*, to discover if any water oozes from cracks or cavities, and also if any enlargement has taken place. The quantity of water that runs out of a crack or honey-comb will indicate the extent of the defect, and if it exceeds a few drops, the gun should be rejected, although the measured depth of the cavity may not exceed the allowance. If the water oozes out between the vent piece and the metal of the gun, a new vent piece must be inserted, and the piece again proved with one charge, and the water proof repeated. After the bore has been reamed out to the proper size, its dimensions are again verified, and an examination of the bore and vent is made, to detect any defects which may have been caused or developed by the proof. *Whitish spots* show a separation of the tin from the copper, and, if extensive, should condemn the piece. A *great variation from the true weight*, which the dimensions do not account for, shows a defect in the alloy. Any attempt to conceal cavities by filling them with screws, or by any other methods, should cause the rejection of the piece.

Brass cannon should be rejected for the following cavities or honey-combs:

Exterior.—Any hole or cavity 0.25 inch deep above the trunnions, and 0.2 inch deep at or behind the trunnions.

Interior.—From the muzzle to the reinforce, any cavity 0.15 inch deep. Any cavity from the reinforce to the bottom of the bore.

VARIATIONS ALLOWED IN THE DIMENSIONS OF BRASS CANNON.

	Inch.
Length of bore, more or less -	0.1
Diameter of bore, - { more -	0.03
{ less -	0.00
Exterior position of vent, more or less -	0.05
Interior position of vent, more or less -	0.20

					Inch.
Diameter of vent,	{ more	-	-	-	0.01
	{ less	-	-	-	0.00
Diameter of trunnions,	{ more	-	-	-	.00
	{ less	-	-	-	.025
Length of trunnions,	{ more	-	-	-	.10
	{ less	-	-	-	.05
Position of trunnions,	{ above the axis of the gun	-	-	-	.00
	{ below the axis of the gun	-	-	-	.20
	{ out of alignment	-	-	-	.00
Distance from rear of base ring to rear of trunnions	-	-	-	-	.10
Distance between rimbases, less	-	-	-	-	.04
Length from the base ring to the muzzle, more or less	-	-	-	-	.10
Position of mouldings, more or less	-	-	-	-	.10
Any exterior diameter from the base ring to the muzzle, inclusive, and	-	-	-	-	
diameter of rimbases, more or less	-	-	-	-	.04
Diameter of cascable, neck, and knob, more or less	-	-	-	-	.05

A proper discretion must be exercised in the inspection of cannon; such slight imperfections as do not injure a piece for service may be disregarded, whilst the instructions should be strictly enforced with regard to defects which may impair its utility.

PROOF OF CANNON.

Gunpowder for proving cannon should be of the best quality, ranging not less than 250 yards by the eprouvette; it should be proved immediately before being used, unless it shall have been proved within one year previously, and there be no reason to suspect that it has become deteriorated. The cartridge bags are made of flannel or wildbore, or of paper cylinders with flannel bottoms, like those for ordinary service; they are filled by weight, and if not filled at the place where the guns are proved, each bag should be enveloped in a paper cylinder and cap, marked with the weight of powder and its proof range.

The *shot* must be smooth, free from seams and other inequalities that might injure the bore of the piece, and they must be of the true diameter given in the tables.

The *wads* are made of junk, as described in *Chapter 9*.

IRON CANNON.

Guns and *howitzers* are laid with the muzzles resting on a block of wood and the breech on the ground, or on a thick plank, giving the bore a small elevation.

Mortars are mounted on strong wooden frames or beds, at an elevation of 45° , supported by the trunnions.

In proving iron cannon, after pricking the cartridge, prime with powder or a tube and place over the vent a piece of portfire set in clay or putty, and long enough to permit the man who fires it to reach a place of safety before the charge explodes.

Iron guns are fired with the following charges:

1ST AND 2D ROUNDS.—A charge of powder equal to *one-half* of the weight of the shot; two *shot* and two *wads*.

3D ROUND.—A charge of powder equal to *one-third* of the weight of the shot; one shot and two wads.

In proving *new* guns, a cylinder with hemispherical ends, of the true diameter of the shot and equal in weight to the two shot, shall be used instead of them.

One wad is placed over the powder, and the other over the cylinder or the upper ball, the whole being well rammed.

Should any of the guns proved at one time fail to sustain the above proof, the remainder shall be again fired *twice* with a charge of powder equal to *one-half* of the weight of the shot, *one shot and two wads*; and if, in either or both of these trials, *one-fourth* of the whole number should fail, the whole shall be rejected.

Other iron cannon are fired twice with the following charges:

Howitzers.

SEA COAST, 10 inch.—15 lbs. of powder, 1 10-inch shot, and 1 wad over the shot.

Do. 8 inch.—12 lbs. of powder, 1 8-inch shot, and 1 wad over the shot.

SIEGE, 8 inch.—4 lbs. of powder, 1 8-inch shot, and 1 wad over the shot.

FIELD, 24 pdr.—3 lbs. of powder, 1 24-pdr. shot, and 1 wad over the shot.

Do. 12 pdr.—2 lbs. of powder, 1 12-pdr. shot, and 1 wad over the shot.

Mortars.

HEAVY, 13 inch.—20 lbs. of powder, 1 13-inch shot.

Do. 10 inch.—10 lbs. of powder, 1 10-inch shot.

LIGHT, 10 inch.—5 lbs. of powder, 1 10-inch shot.

Do. 8 inch.— $2\frac{1}{2}$ lbs. of powder, 1 8-inch shot.

Should any *howitzer* or *mortar* fail to sustain the above proof, the remainder of those offered at the same time shall be again fired *twice* with the same charge; and if, in either or both of these trials, *one-fourth* of the whole number should fail, the whole shall be rejected.

The *water proof*, as described for brass cannon, must also be applied to iron cannon for field service and occasionally to other iron cannon, at the discretion of the inspector.

The bore and vent and the exterior surface of every piece which is approved, should be well covered with sperm oil immediately after the inspection.

BRASS CANNON.

Are mounted on appropriate carriages or beds; they are fired three times. *Guns* and *howitzers* at an elevation of 5° , *mortars* at an elevation of 45° ; with the following charges:

Field guns.

A charge of *powder* equal to *one-third* of the weight of the shot, one *shot* and two *wads*.

Howitzers.

FIELD, 24-pdr.— $2\frac{1}{2}$ lbs. of powder, 1 shot and 1 wad.

Do. 12-pdr.— $1\frac{1}{2}$ lbs. of powder, 1 shot and 1 wad.

MOUNTAIN, 12-pdr.— $\frac{3}{4}$ lb. of powder, 1 shot and 1 wad.

Mortars.

STONE MORTAR.— $2\frac{1}{2}$ lbs. of powder, covered by a wooden tompion 2 inches thick; a basket filled with alternate layers of stones and earth, weighing 100 lbs.

COEHORN, 24 pdr.— $\frac{3}{4}$ lb. of powder, 1 24-pdr. shot.

In proving brass cannon in service, or after they have been bored to the proper calibre, the shot should be wrapped in cloth or strong paper to save the bore as much as possible from injury.

MARKS.

All cannon are required to be weighed and to be marked, as follows, viz: the *number of the gun*, and the *initials of the inspector's name*, on the face of the muzzle; the numbers in a separate series for each kind and calibre at each foundry; the initial letters of the *name of the founder* and of the foundry, on the end of the right trunnion; the *year of fabrication* on the end of the left trunnion; the *weight of the piece in pounds* on the base of the breech; in guns and howitzers, below the centre; in mortars, above it; the letters U. S. on the upper surface of the piece, near the end of the reinforce.

Cannon rejected on inspection, are marked X C, on the face of the muzzle, near the initials of the inspector's name; if condemned for erroneous dimensions which cannot be remedied, add X D; if by powder proof, X P; if by water proof, X W.

Injuries caused by service.

Brass cannon are little subject to external injury, except from the bending of the trunnions sometimes after long service, or heavy charges.

Internal injuries are caused by the action of the elastic fluids developed in the combustion of the powder, or by the action of the shot in passing out of the bore. These effects generally increase with the calibre of the piece.

Of the first kind, which exhibit themselves in rear of the shot, are: *the enlargement of the bore* by the compression of the metal, which is seldom a serious defect; *corrosion of metal*, particularly at the angles, such as the inner orifice of the vent, the mouth of a cylindrical chamber; *cracks*, from the yielding of the cohesion of the metal; *cavities*, cracks enlarged by the action of the gas, and by the melting of the metal; observable especially in the upper surface of the bore.

Injuries of the second kind, which appear in front of the cartridge, are: *the lodgment of the shot*, a compression of the metal on the lower side of the bore, at the seat of the shot, caused by the pressure of the fluid in escaping over the top of the shot; there is a corresponding *burr* in front of the lodgment and the motion thereby given to the shot causes it to strike alternately on the top and bottom of the bore, producing other *enlargements*, generally *three* in number; the first, on the upper side, a little in advance of the trunnions; the second, on the lower side, about the astragal; the third, in the upper part of the muzzle; it is chiefly from this cause that brass guns become unserviceable; the extent of the injury varies according to the length of the bore: *scratches* caused by the fragments of a broken shot, or the roughness of an imperfect one: *enlargement of the muzzle* by the striking of the shot in leaving the bore; *exterior cracks*, or longitudinal splits, caused by too great a compression of the metal on the interior.

The durability of brass cannon may be much increased by careful use, and by the precautions of *increasing the length of the cartridge*, or that of the *sabot*, or using *a wad over the cartridge*, in order to change the place of the shot; by *wrapping the shot in woollen or other cloth*, or in *paper*, so as to diminish the windage and the bounding of the shot in the bore. In *field guns*, both brass and iron, the paper cap which is taken off from the cartridge should always be put over the shot.

Iron cannon are subject to the above defects in a less degree than brass, except the corrosion of the metal, by which the vent especially is rendered unserviceable from enlargement. The principal cause of injury to iron cannon is the *rusting* of the metal, producing a roughness and enlargement of the bore and an increase of any cavities or *honey combs* which may exist in the metal.

The service to which an iron cannon has been subjected may generally be determined by the appearance of the vent.

Spiking and unspiking cannon, and rendering them unserviceable.

To spike a piece: drive into the vent a jagged and hardened steel spike with a soft point, or a nail without a head; break it off flush with the outer surface and clinch the point inside by means of the rammer; wedge a shot in the bottom of the bore by wrapping it with felt, or by means of iron wedges, using the rammer or a bar of iron to drive them in; a wooden wedge would be easily burnt by means of a charcoal fire lighted with the aid of a bellows: cause shells to burst in the bore of brass guns, or fire broken shot from them with high charges. Fill a piece with sand over the charge to burst it. Fire a piece against another, muzzle to muzzle, or the muzzle of one to the chase of the other. Light a fire under the chase of a brass gun, and strike on it with a sledge to bend it. Break off the trunnions of iron guns, or burst them by firing them with heavy charges and full of shot, at a high angle.

When guns are to be spiked temporarily and are likely to be retaken, a *spring spike* is used, having a shoulder to prevent its being too easily extracted.

To unspike a piece: if the spike is not screwed in or clinched, and the bore is not impeded, put in a charge of powder of $\frac{1}{3}$ the weight of the shot and ram junk wads over it with a handspike, laying on the bottom of the bore a strip of wood with a groove on the under side containing a strand of quick match by which fire is communicated to the charge; in a brass gun, take out some of the metal at the upper orifice of the vent, and pour sulphuric acid into the groove for some hours before firing. If this method, several times repeated, is not successful, unscrew the vent piece, if it be a brass gun, and if an iron one, drill out the spike, or drill a new vent.

To drive out a shot wedged in the bore: unscrew the vent piece, if there be one, and drive in wedges so as to start the shot forward, then ram it back again in order to seize the wedge with a hook, or pour in powder and fire it, after replacing the vent piece. In the last resort, bore a hole in the bottom of the breech, drive out the shot, and stop the hole with a screw.

Preservation of cannon.

Cannon should be placed together, according to kind and calibre, on skids of stone, iron, or wood, laid on hard ground well rammed and covered with a layer of cinders, or of some other material, to prevent vegetation.

Guns and long howitzers.—The pieces should rest on the skids in front of the base ring and in rear of the astragal; the axis inclined at an angle of 4 or 5 degrees with the horizontal, the muzzle lowest; the trunnions touching each

other, or if space is wanting for that arrangement, the trunnion of one piece may rest on the adjoining piece, so that the axis of the trunnions is inclined about 45° with a horizontal line; the vent down, stopped with a greased wooden plug, or with putty or tallow. If circumstances require it, the pieces may be piled in two tiers, with skidding placed between them, exactly over those which rest on the ground; the muzzles of both tiers in the same direction and their axes preserving the same inclination.

Short howitzers and mortars.—On thick planks, standing on their muzzles, the trunnions touching, the vents stopped.

Iron cannon should be covered on the exterior with a lacker impervious to water, (see chap. 13;) the bore and the vent should be greased with a mixture of oil and tallow, or of tallow and beeswax melted together and boiled to expel the water. The lacker should be renewed as often as requisite, and the grease, every year.

The lacker and grease should be applied in hot weather.

The cannon should be frequently inspected, to see that moisture does not collect in the bore.

CANNON OF FOREIGN COUNTRIES.

The materials for the following table have been collected, with few exceptions, from the latest manuals of artillery in England, France, Prussia, and Austria, and from memoranda obtained in Russia and Sweden.

The dimensions and weights are given in our own measures.

The column of *exterior length* shows the length from the rear of the base ring to the face of the piece, and the *length of bore* includes the chamber, when not otherwise mentioned.

In *England, France, and Sweden*, howitzers and mortars take their denominations, as with us, from the diameter of the bore, or from the calibre of a gun of corresponding bore; in *Austria and Prussia*, from the weight of a stone ball of the calibre of the bore; in *Russia*, from the true weight of the shell.

CANNON OF FOREIGN COUNTRIES.

DESIGNATION.	DIAMETER OF BORE.	DIAMETER OF BALL.		BRONZE.			IRON.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
ENGLAND.	Inch.	Inch.	Inch.	Inch.	Inch.	lbs.	Inch.	Inch.	lbs.
BOMB CANNON.—12-in. -	12.	11.88	11.80	-	-	-	100.	-	10,000
10-in. -	10.	9.88	9.80	-	-	-	112.	110.	9,500
8-in. -	8.05	7.95	7.90	-	-	-	108.	106.	7,280
8-in. -	8.05	7.95	7.90	-	-	-	102.	100.	6,750
8-in. -	8.05	7.95	7.90	-	-	-	96.	94.	5,824
GUNS.—42-pdr. -	7.00	6.79	6.72	114	-	7,280	114.	107.	7,300
New naval,	32-pdr. -	6.41	6.20	6.14	-	-	114.	109.	7,000
	32-pdr. -	6.37	6.20	6.14	-	-	108.	-	5,600
	32-pdr. -	6.35	6.20	6.14	-	-	102.	-	5,000
	32-pdr. -	6.35	6.20	6.14	-	-	96.	-	4,700
	24-pdr. -	5.82	5.63	5.58	114	5,935	114.	107.41	5,600
	24-pdr. -	5.82	5.63	5.58	75	2,700	108.	101.45	5,320
	18-pdr. -	5.29	5.12	5.07	69	2,000	108.	101.75	4,700
	18-pdr. -	5.29	5.12	5.07	-	-	96.	89.74	4,200
	12-pdr. -	4.62	4.47	4.43	78	74.55	102.	96.22	3,700
	12-pdr. -	4.62	4.47	4.43	60	56.61	72.	-	2,350
	9-pdr. -	4.2	4.10	4.06	-	-	102.	96.48	3,200
	9-pdr. -	4.2	4.10	4.06	-	-	90.	84.44	2,912
	9-pdr. -	4.2	4.10	4.06	72	67.74	84.	78.48	2,800
	6-pdr. -	3.66	3.56	3.53	84	80.35	102.	96.96	2,600
	6-pdr. -	3.66	3.56	3.53	60	57.47	72.	66.97	1,900
CARRONADES.—	3-pdr. -	2.91	2.83	2.80	72	64.45	-	-	-
	3-pdr. -	2.91	2.83	2.80	48	46.00	-	-	-
	3-pdr. -	2.91	2.83	2.80	36	34.00	-	-	-
	1-pdr. -	2.01	1.99	1.92	60	60.00	-	-	-
	68-pdr. -	8.05	7.95	7.9	-	-	64.	64.	4,032
	42-pdr. -	6.84	6.79	6.72	-	-	54.	54.	2,464
	32-pdr. -	6.25	6.2	6.14	-	-	48.	48.	1,900
	24 pdr. -	5.68	5.63	5.58	-	-	45.	45.	1,456
	18-pdr. -	5.16	5.12	5.07	-	-	40.	40.	1,120
	12-pdr. -	4.52	4.47	4.43	-	-	32.	32.	672
HOWITZERS.—	10-in. -	10.	9.88	9.8	48	2,900	60.	58.75	4,480
	8-in. -	8.	7.90	7.82	37	1,440	48.	46.80	2,350
	24-pdr. -	5.72	5.62	5.57	56.6	1,456	-	-	-
	5½-in. -	5.62	5.62	5.57	33	1,120	46.	-	1,680
	12-pdr. -	4.58	4.47	4.43	45.2	728	-	-	-
MORTARS.—	4 2-5-in. -	4.52	4.47	4.43	22	280	-	-	-
	Sea, { 13-in. -	13.	12.88	12.80	63.	9,192	52.	39.	11,200
	Land. {	10-in. -	10.	9.88	56.	3,696	45.	35.	5,800
		13-in. -	13.	12.88	43.50	2,800	36.	26.	4,100
		10-in. -	10.	9.88	27.00	1,380	28.	20.	1,800
		8 in. -	8.	7.90	21.	728	22.5	16.	900
FRANCE.	5½-in. -	5.62	5.62	5.57	15.	140	-	-	-
	4 2-5-in. -	4.52	4.47	4.43	12.	84	-	-	-
	GUNS.—								
	48-pdr. -	7.404	7.329	7.248	152.17	11,775	-	-	-
	24-pdr. -	6.011	5.878	5.804	127.33	6,067	-	-	-
Siege and gar- rison.	16-pdr. -	5.264	5.130	5.056	122.34	4,432	-	-	-
	12-pdr. -	4.775	4.686	4.620	115.48	3,432	-	-	-
	8-pdr. -	4.175	4.088	4.021	104.24	2,345	-	-	-

DESIGNATION.	DIAMETER OF BORE.	DIAMETER OF BALL.		BRONZE.			IRON.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
	Inch.	Inch.	Inch.	Inch.	Inch.	lbs.	Inch.	Inch.	lbs.
FRANCE.—Continued.									
GUNS.—									
Field,	12-pdr. -	4.775	4.686	4.620	83.15	78.86	1,959	-	-
	8-pdr. -	4.175	4.088	4.021	72.49	68.74	1,279	-	-
	4-pdr. -	3.316	3.228	3.154	57.57	54.61	636	-	-
	36-pdr. -	6.885	6.685	6.641	-	-	115.13	107.32	7,734
	Long 30-pdr. -	6.485	6.307	6.263	-	-	110.91	104.01	6,684
	Short 30-pdr. -	6.485	6.307	6.263	-	-	102.00	96.81	5,476
	Long 24-pdr. -	6.004	5.826	5.782	-	-	108.74	101.90	5,519
	Short 24-pdr. -	6.004	5.826	5.782	-	-	100.00	95.31	4,658
	Long 18-pdr. -	5.463	5.308	5.264	-	-	102.34	95.94	4,543
	Short 18-pdr. -	5.463	5.308	5.264	-	-	94.56	90.10	3,780
	Long 12-pdr. -	4.775	4.641	4.597	-	-	95.94	90.35	3,230
	Short 12-pdr. -	4.775	4.641	4.597	-	-	87.23	83.15	2,585
	Long 8-pdr. -	4.175	4.064	4.020	-	-	102.34	97.45	2,573
	Short 8-pdr. -	4.175	4.064	4.020	-	-	87.42	82.53	2,216
	Long 6-pdr. -	3.790	3.679	3.635	-	-	89.55	85.11	1,868
	Short 6-pdr. -	3.790	3.679	3.635	-	-	78.89	74.45	1,650
CARRONADES.—									
	36-pdr. -	6.796	6.685	6.641	-	-	53.34	45.03	2,524
	30-pdr. -	6.419	6.307	6.263	-	-	53.33	45.85	2,227
	24-pdr. -	5.937	5.826	5.782	-	-	45.71	38.36	1,663
	18-pdr. -	5.419	5.308	5.264	-	-	41.71	34.65	1,272
	12-pdr. -	4.753	4.642	4.597	-	-	35.33	29.37	840
BOMB CANNON.—									
Naval,	10-in. -	10.630	-	-	-	-	*124.00	110.84	11,000
	8-in. -	8.795	8.703	8.624	-	-	98.08	92.21	8,000
	8-in. -	8.664	-	-	-	-	*100.13	92.14	5,740
	8-in. -	8.664	-	-	-	-	*85.25	78.00	3,530
	30-pdr. -	6.574	-	-	-	-	*90.41	84.18	3,350
HOWITZERS.—									
Sea coast,	8-in. -	8.821	8.703	8.624	-	-	98.45	92.55	5,510
Siege,	Old 8-in. -	8.795	8.703	8.624	37.05	33.85	1,182	-	-
	New 8-in. -	8.782	8.703	8.624	52.00	39.38	2,646	-	-
Field,	Old 6-in. -	6.530	6.441	6.396	30.25	27.05	700	-	-
	New 6-in. -	6.518	6.441	6.396	74.23	70.29	1,951	-	-
	do. 24-pdr. -	5.947	5.878	5.834	67.54	63.60	1,281	-	-
Mountain,	12-pdr. -	4.745	4.686	4.639	33.87	31.90	221	-	-
MORTARS.—									
Gomer,	12-in. -	12.793	12.659	12.571	35.27	27.45	2,922	-	-
	10-in. -	10.794	10.705	10.616	30.29	22.83	2,296	-	-
	8-in. -	8.795	8.706	8.617	21.72	17.46	607	-	-
Mountain,	24-pdr. -	5.95	5.878	5.834	16.70	14.10	154	-	-
Stone	-	15.991	-	-	31.63	26.70	1,617	-	-
AUSTRIA.									
GUNS.—									
Mountain,	1-pdr. -	2.075	1.981	1.959	31.37	29.41	180	-	-
	3-pdr. -	2.957	2.849	2.827	31.64	29.16	296	-	-
Field,	3-pdr. -	2.957	2.849	2.827	45.25	42.42	508	-	-
	6-pdr. -	3.724	3.594	3.562	57.00	53.43	842	-	-
	12-pdr. -	4.660	4.524	4.488	71.82	67.33	1,700	-	-
	18-pdr. -	5.311	5.173	5.137	82.22	77.71	2,514	-	-

* Attached to a stock. † Cast with a bed plate.

FOREIGN CANNON.

DESIGNATION.	DIAMETER OF BORE.	DIAMETER OF BALL.		BRONZE.			IRON.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
	Inch.	Inch.	Inch.	Inch.	Inch.	lbs.	Inch.	Inch.	lbs.
AUSTRIA—Continued.									
GUNS.—									
Siege and gar- rison,	6-pdr. -	3.724	3.594	3.562	-	-	92.47	88.90	1,566
	12-pdr. -	4.660	4.524	4.488	112.22	108.01	111.85	106.61	3,445
	18-pdr. -	5.311	5.173	5.137	123.32	118.50	117.86	111.76	4,789
	24-pdr. -	5.827	5.691	5.655	130.08	124.78	-	-	-
BOMB CANNON,	30-pdr. -	9.473	9.350	9.256	-	-	98.31	92.39	8,558
HOWITZERS,	7-pdr. -	5.870	5.755	5.698	34.55	31.70	34.55	31.70	498
	10-pdr. -	6.634	6.512	6.418	35.71	31.68	-	-	-
MORTARS.—									
Coehorn,	6-pdr. -	3.724	3.594	3.562	-	-	10.91	9.35	68
	10-pdr. -	6.634	6.512	6.418	22.47	18.91	-	-	-
	30-pdr. -	9.494	9.350	9.256	27.77	22.63	-	-	-
	30-pdr. -	9.422	9.350	9.256	28.35	23.58	-	-	-
	60-pdr. -	11.922	11.763	11.663	32.44	25.97	-	-	-
STONE MORTAR,	60 pdr. -	12.390	-	-	-	-	38.45	32.44	2,180
PRUSSIA.									
GUNS.—									
Field,	6-pdr. -	3.711	3.629	3.536	63.91	61.03	-	-	-
	12-pdr. -	4.680	4.573	4.460	80.40	76.64	-	-	-
	3-pdr. -	2.948	2.886	2.804	57.72	55.00	-	-	800
Siege and gar- rison,	6-pdr. -	3.711	3.629	3.536	-	-	59.79	55.66	1,019
	12-pdr. -	4.680	4.573	4.460	106.68	102.57	107.20	101.84	3,054
	24-pdr. -	5.855	5.752	5.639	119.17	113.39	119.17	112.46	5,897
	24-pdr. -	5.855	5.752	5.639	71.94	67.21	72.87	67.21	2,842
HOWITZERS.—									
Field,	7-pdr. -	5.845	5.752	5.639	39.17	35.05	-	-	-
	10-pdr. -	6.741	6.633	6.520	42.26	38.40	-	-	-
Siege and garri- son,	25-pdr. -	8.927	8.834	8.710	54.80	53.66	54.80	53.66	3,426
MORTARS.—									
Hand,	-	3.092	-	*	5.21	15½	-	-	-
	-	4.618	4.573	4.460 †	7.63	39	-	-	-
	7-pdr. -	5.793	5.752	5.639	15.86	13.02	-	-	-
	10-pdr. -	6.690	6.633	6.520	20.61	15.97	21.64	15.97	627
	25-pdr. -	8.906	8.834	8.710	26.29	21.65	27.83	21.65	1,129
	50-pdr. -	11.184	11.102	10.978	36.69	29.89	37.87	29.89	2,165
	Stone -	15.454	-	-	-	-	33.00	25.77	1,553
BOMB CANNON,	50-pdr. -	11.120	11.102	10.978	-	-	111.00	-	12,400
RUSSIA.									
GUNS.—									
Field,	6-pdr. -	3.762	3.646	3.609	-	51.13	-	-	-
	12-pdr. -	4.739	4.610	4.560	-	74.64	-	-	-
	3-pdr. -	2.996	2.920	2.880	-	-	51.00	48.00	681
Siege and gar- rison and sea coast,	6-pdr. -	3.762	3.646	3.609	-	-	82.70	79.00	1,665
	12-pdr. -	4.739	4.610	4.560	-	100.00	104.00	99.00	3,300
	18-pdr. -	5.426	5.300	5.210	-	108.75	114.00	106.50	5,680
	24-pdr. -	5.972	5.860	5.784	-	119.70	126.00	118.00	7,600
	30-pdr. -	6.443	6.320	6.240	-	-	129.00	121.15	9,080
	36-pdr. -	6.837	6.750	6.650	-	-	136.00	127.70	10,500

* Attached to a stock. † Cast with a bed plate.

DESIGNATION.	DIAMETER OF BORE.	DIAMETER OF BALL.		BRONZE.			IRON.		
		High gauge.	Low gauge.	Length.		Weight.	Length.		Weight.
				Exterior.	Bore.		Exterior.	Bore.	
	Inch.	Inch.	Inch.	Inch.	Inch.	lbs.	Inch.	Inch.	lbs.
RUSSIA—Continued.									
HOWITZERS, (Likorna.)									
Field, { 3-pdr. -	3.242	3.140	3.100	Exclusive of chamber.	28.37	240	-	-	-
10-pdr. -	4.843	4.700	4.650		37.53	707	-	-	-
10-pdr. -	4.843	4.700	4.650		42.38	780	-	-	-
20-pdr. -	6.102	5.990	5.915		50.34	1,509	}	50.34	1,675
Siege and garri- son - 40-pdr. -	7.688	7.575	7.476		63.90	3,170		63.43	3,476
MORTARS.—									
6-pdr. -	4.084	3.920	3.890		7.00	26	-	-	-
80-pdr. -	9.650	9.570	9.490		14.50	1,311		16.00	1,927
200-pdr. -	13.150	13.050	12.950		18.81	3,243		21.83	4,900
BOMB CANNON.—									
20-pdr. -	6.000	5.990	5.915	-	-	-	92.00	87.00	3,300
40-pdr. -	7.700	7.575	7.476	-	-	-	116.00	110.00	5,600
96-pdr. -	9.000	8.900	8.820						
120-pdr. -	10.750	10.680	10.580						
SWEDEN.									
GUNS.—									
Field, { 3-pdr. -	3.015	2.922	2.887						
6-pdr. -	3.786	3.687	3.652	-	-	-	65.60	62.50	816
12-pdr. -	4.791	4.674	4.628	-	-	-	81.70	77.75	1,565
18-pdr. -	5.551	5.446	5.388	-	-	-			
24 pdr. -	6.112	5.994	5.924	-	-	-			
Ship, { 30-pdr. -	6.560	6.455	6.385	-	-	-	74.00	70.00	3,636
30-pdr. -	6.560	6.455	6.385	-	-	-			6,276
HOWITZERS.—									
Field,* { 12-pdr. -	4.791	4.674	4.628	-	-	-	53.77	50.62	830
24-pdr. -	6.112	5.994	5.924	-	-	-	68.39	64.53	1,550
MORTARS.—									
7.in. -	8.905	8.765	8.695	-	-	-	33.78	29.23	1,050
Light 9.in. -	11.254	11.114	11.021	-	-	-	39.04	33.30	2,100
Heavy 9.in. -	11.254	11.114	11.021				52.84	44.66	4,800
11.in. -	12.855	12.715	12.598						

*Not chambered.

CHAPTER SECOND

SHOT AND SHELLS.

NOMENCLATURE, DIMENSIONS, WEIGHTS.

<i>Shot.</i>								
Calibre of	42	32	24	18	12	9	6	3
	In.	In.	In.	In.	In.	In.	In.	In.
True diameter -	6.83	6.24	5.68	5.17	4.52	4.1	3.58	2.83
Diameter of large gauge -	6.86	6.27	5.70	5.18	4.53	4.12	3.60	2.84
Diameter of small gauge -	6.76	6.18	5.61	5.10	4.46	4.05	3.54	2.80
Mean weight, lbs. -	43.33	33.04	24.92	18.79	12.56	9.37	6.24	3.08
<i>Shells.</i>								
Calibre of	13-in.	10-in.	8-in.	42	32	24	18	12
	In.	In.	In.	In.	In.	In.	In.	In.
True diameter -	12.85	9.85	7.85	6.83	6.24	5.68	5.17	4.52
Diameter of large gauge	12.90	9.90	7.90	6.86	6.27	5.70	5.18	4.53
Diameter of small gauge	12.80	9.80	7.80	6.76	6.18	5.61	5.10	4.46
Thickness of metal. { True -	2.10	1.60	1.25	1.15	1.00	0.85	0.80	0.70
{ Greatest -	2.25	1.70	1.33	1.20	1.05	0.90	0.84	0.74
{ Least -	1.95	1.50	1.17	1.10	0.95	0.80	0.76	0.66
Diameter of fuze hole. { Exterior -	1.75	1.60	1.20	1.20	1.20	0.90	0.90	0.90
{ Interior -	1.60	1.50	1.10	1.10	1.10	0.80	0.80	0.80
Distance between the ears -	7.	6.	5.	-	-	-	-	-
Mean weight, lbs. -	200	89.39	44.62	30.38	22.41	16.22	12.50	8.33

The *ears* of a shell are holes for the points of the shell hooks, 0.5 inch in diameter, bored opposite to each other, and perpendicular to the axis of the fuze hole; the metal is cut out above them at the distance indicated in the table, in a direction perpendicular to the axis of the holes, which must remain 0.25 inch deep, with a thickness of 0.25 inch of metal above them, at the thinnest part.

Carcasses,

Are shells with three additional holes of the same dimensions as the fuze hole, pierced at equal distances apart in the upper hemisphere of the shell, with their exterior openings tangent to the great circle which is perpendicular to the axis of the fuze hole.

Calibre of	13-in.	10-in.	8-in.	42	32	24	18	12
Mean weight, lbs.	194	87.63	43.62	29.45	21.60	15.84	12.15	8

Spherical case shot.

Calibre of			8-in.	42	32	24	18	12	6	
			In. the	In. same	In. as	In. for	In. shot	In. and	In. shells.	
Diameters of shot and of gauges										
Thickness of metal at the sides.	{	True	-	0.7	0.65	0.60	0.55	0.5	0.45	0.36
		Greatest	-	0.725	0.675	0.625	0.575	0.525	0.475	0.385
		Least	-	0.675	0.625	0.575	0.525	0.475	0.425	0.335
Thickness of metal at the fuze hole			-	1.6	1.5	1.5	1.1	1.1	0.75	0.75
Radius of reinforce at the fuze hole			-	3.0	2.75	2.5	2.3	2.1	1.8	1.4
Diameter of fuze hole.	{	Exterior	-	1.2	1.2	1.2	0.9	0.9	0.9	0.9
		Interior	-	1.1	1.1	1.1	0.8	0.8	0.8	0.8
Mean weight,			lbs.	30.	20.32	15.63	11.86	8.93	6.11	3.06

The thickness of metal at the fuze hole is supposed to be measured in the axis of the fuze hole between the spherical surfaces of the shell and of the reinforce.

Grape shot.

Calibre of	8-in.	42	32	24	18	12
	In.	In.	In.	In.	In.	In.
Diameter of large gauge	3.60	3.17	2.90	2.64	2.40	2.06
Diameter of small gauge	3.54	3.13	2.86	2.60	2.36	2.02
Mean weight, lbs.	6.24	4.25	3.25	2.45	1.83	1.19

Canister shot.

	NATURE OF ORDNANCE.									
	42	32	24 and 8-in. howitzer.	18	12	9 and 24-pdr. howitzer.	6	12-pdr. how- itzer.		
								Field.	Moun- tain.	
	In.	In.	In.	In.	In.	In.	In.	In.	Musket ball.	
Diameter of large gauge	2.26	2.06	1.87	1.70	1.49	1.35	1.17	1.08		
Diameter of small gauge	2.22	2.02	1.84	1.67	1.46	1.32	1.14	1.05		
Mean weight, lbs.	1.57	1.19	0.90	0.67	0.45	0.33	0.235	0.17		0.056

Grape and canister shot are of cast iron. The old shot of this kind which are found at the arsenals and which do not correspond with the dimensions above given, should be used in the most advantageous manner which circumstances may admit of, in making up stands of grape and canister, for which see *Chapter 9*.

Grenades.

Six-pounder spherical case shot may be used for *hand grenades*, and small shells of any calibre for *rampart grenades*.

Lead balls.

DIAMETERS OF LEADEN BALLS FROM 1 TO 32 TO THE POUND.

No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.	No. of balls to 1 lb.	Diameter.
	In.		In.		In.		In.
1	1.670	9	0.803	17	0.650	25	0.571
2	1.326	10	.775	18	.638	26	.564
3	1.157	11	.751	19	.626	27	.557
4	1.051	12	.730	20	.615	28	.550
5	1.977	13	.710	21	.605	29	.544
6	.919	14	.693	22	.596	30	.537
7	.873	15	.676	23	.587	31	.531
8	.835	16	.663	24	.579	32	.526

For the mode of fabrication of leaden balls, see *Chapter 9*.

DIAMETERS OF CAST IRON BALLS FROM $\frac{1}{4}$ POUND TO 50 POUNDS WEIGHT.

Weight.	Diam.	Weight.	Diam.	Weight.	Diam.	Weight.	Diam.
lbs. oz.	In.	lbs.	In.	lbs.	In.	lbs.	In.
4	1.225	9	4.044	23	5.528	37	6.478
6	1.402	10	4.188	24	5.608	38	6.535
8	1.543	11	4.323	25	5.684	39	6.592
10	1.663	12	4.450	26	5.759	40	6.649
12	1.766	13	4.571	27	5.832	41	6.703
14	1.859	14	4.685	28	5.903	42	6.757
1	1.944	15	4.794	29	5.972	43	6.810
2	2.449	16	4.898	30	6.040	44	6.863
3	2.804	17	4.998	31	6.107	45	6.914
4	3.086	18	5.095	32	6.172	46	6.965
5	3.324	19	5.187	33	6.235	47	7.015
6	3.532	20	5.277	34	6.297	48	7.065
7	3.719	21	5.363	35	6.359	49	7.113
8	3.888	22	5.447	36	6.419	50	7.161

To find the weight of a cast iron shot or shell :

Multiply the cube of the diameter of the shot in inches, or the difference of the cubes of the exterior and interior diameters of the shell, by 0.136 for the weight in pounds.

For leaden balls, the multiplier is 0.2142.

To find the diameter of a cast iron shot of a given weight :

Divide the weight in pounds by 0.136, and the cube root of the quotient will be the diameter in inches. Or, divide the cube root of the weight in pounds by .514428 for the diameter in inches. Or, from $\frac{1}{3}$ the logarithm of the weight in pounds, subtract—1.7113243, for the logarithm of the diameter in inches.

To find the quantity of powder which a shell will contain :

Multiply the cube of the interior diameter of the shell in inches by 0.01744, for the weight of powder in pounds.

INSPECTION OF SHOT AND SHELLS.

Shot and shells should be made of grey or mottled iron, soft and of good quality, (see CHAP. 12; *cast iron*.) They must be cast in sand, and not in iron moulds; the shot from the latter are generally not spherical in form, nor uniform in size; they are also full of cavities, and are cracked by being heated.

Shot.

Inspecting instruments: One *large* and one *small gauge* and one *cylinder gauge* for each calibre: the cylinder gauge has the same diameter as the large gauge; it is made of cast iron and is 5 calibres long. One *hammer*, weighing half a pound and having a flat face and a conical point.

One *searcher*, of steel wire, with a handle.

The shot should be inspected before they become rusty; after being well cleaned, each shot is placed on a table and examined by the eye to see that its surface is smooth, that the metal is sound and free from seams, flaws and blisters. If cavities or small holes appear on the surface, strike the point of the hammer into them and ascertain their depth with the searcher; if the depth of the cavity exceed 0.2 inch, the shot is rejected; and also if it appear that an attempt has been made to conceal such defects by filling up the holes with nails, cement, &c.

The shot must pass in every direction through the large gauge and not at all through the small one: the founder should endeavor to bring the shot up as near as possible to the *large gauge* or to the *true diameter*: in order to enforce this rule, and also to assist in judging of the sphericity of the shot, it will be useful to apply an *intermediate gauge*, through which the greater part of the shot ought not to pass.

After having been thus examined, the shot are passed through the *cylinder gauge*, which is placed at an inclination of about 2 inches between the two ends and supported on blocks of wood in such a manner as to be easily turned from time to time, to prevent its being worn in furrows. Shot which *slide* or *stick* in the cylinder are rejected; the latter must be pushed out from the lower end with a wooden rammer.

The last proof of shot is to drop them from a height of 20 feet on a block of iron, or to roll them down an inclined plane of that height against another shot at the bottom of the plane.

The average weight of the shot is deduced from that of three parcels of 20 to 50 each, taken indiscriminately from the pile: some of those which appear to be the smallest may be also weighed and they are rejected if they fall short of the weight expressed by their calibre more than one *thirty-second* part. They almost invariably exceed that weight.

Grape and canister shot.

The dimensions are verified by means of a large and a small gauge attached to the same handle.

Shells and hollow shot.

INSPECTING INSTRUMENTS.—A *large* and *small gauge* for each calibre, and a *cylinder gauge* for shells of 8 inches and under.

Callipers with steel points; one limb curved, the other straight, with a point projecting inwards; they have a graduated arc for measuring the thickness of the metal at the sides of the shell.

Sliding callipers, to measure the thickness at the bottom of the shell.

Gauges for the thickness at the fuze hole, cut in a piece of sheet iron.

Gauge for the dimensions of the fuze hole; made of round iron or steel, or of flat iron about 0.25 inch thick, case hardened, with the edges conical, and marked at the point to which it should enter the fuze hole.

A *pair of hand bellows*; a *wooden plug* to fit the fuze hole and bored through to receive the nozzle of the bellows.

A *hammer*; a *searcher*; a *cold chisel*.

The surface of the shell and its exterior dimensions are examined as in the case of shot. The shell is next struck with the hammer to judge by the sound whether it is free from cracks; the position and dimensions of the ears are verified; the thickness of metal is then measured at several points on the great circle perpendicular to the axis of the fuze hole, and at the bottom, and at the fuze hole. The diameter of the fuze hole, which should be accurately reamed, is then verified, and the soundness of the metal about the inside of the hole is ascertained by inserting the finger.

The shell is now placed on a trivet in a tub containing water deep enough to cover it nearly to the fuze hole; the bellows and plug are inserted into the fuze hole and the air forced into the shell; if there are any holes in the shell, the air will rise in bubbles through the water. This test also gives another indication of the soundness of the metal, as the parts containing cavities will dry more slowly than the other parts.

The mean weight of shells is ascertained in the same manner as that of shot.

Shot and shells rejected in the inspection are marked with a X, made with the cold chisel; on shot near the gate, and on shells, near the fuze hole.

PRESERVATION AND PILING OF BALLS.

Balls should be carefully lackered as soon as possible after they are received: for the composition of lacker and the manner of applying it, see *Chap. 9*.

When it becomes necessary to renew the lacker, the old lacker should be removed by scraping the ball which should never be heated for that purpose.

Balls are piled according to kind and calibre, under cover if practicable, or if not, in a place where there is a free circulation of air, to facilitate which the

piles should be made narrow if the locality permits; the width of the bottom tier may be from 12 to 14 balls according to the calibre.

Prepare the ground for the base of the pile by raising it above the surrounding ground so as to throw off the water; level it, ram it well, and cover it with a layer of screened sand. Make the bottom of the pile with a tier of unserviceable balls buried about two-thirds of their diameter in the sand; this base may be made permanent: clean the base well and form the pile, putting the fuze holes of shells downwards, in the *intervals*, and not resting on the shells below. Each pile is marked with the number of serviceable balls it contains.

If there are no unserviceable balls, the base may be made of bricks or stone, or of plank, with raised borders strongly spiked down, and picketed, if necessary, on the outside.

Grape and canister shot should be put in bins or strong boxes on the ground floor, or in dry cellars; each parcel marked with its kind, calibre, and number.

To find the number of balls in a pile.

Multiply the sum of the three parallel edges by one-third of the number of balls in a triangular face.

In a square pile, one of the parallel edges contains but one ball; in a triangular pile, two of the edges have but one ball in each.

The number of balls in a triangular face is $\frac{n(n+1)}{2}$; n being the number in the bottom row.

The sum of the three parallel edges in a triangular pile is $n+2$; in a square pile, $2n+1$; in an oblong pile, $3N+2n-2$; N being the length of the top row, and n the width of the bottom tier: or, $3m-n+1$; m being the length and n the width of the bottom tier.

If a pile consist of two piles joined at a right angle, calculate the contents of one as a common oblong pile, and of the other as a pile of which the three parallel edges are equal.

When the length of the bottom tier does not exceed 21, the number of balls in any pile may be found by the following table:

21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Sum of 3 Edges	1/3 of Triangular Face
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	10	10
30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	9	9
29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	8	8
28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	7	7
27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	6	6
26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	5	5
25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	4	4
24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	3	3
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	2	2
22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	1	1
21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	0	0

TABLE OF THE NUMBER OF BALLS IN A PILE OF WHICH THE THREE PARALLEL EDGES ARE EQUAL.

TABLE OF THE NUMBER OF BALLS IN ANY PILE THE BASE OF WHICH DOES NOT EXCEED TWENTY-ONE BALLS.

Tri.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2	4	10	20	35	56	84	120	165	220	286	364	455	560	680	816	969	1140	1330	1540	1771
3	5																			
4	8	14	30																	
5	11	20	40	55																
6	14	26	50	70	91															
7	17	32	60	85	112	140														
8	20	38	70	100	133	168	204													
9	23	44	80	115	154	196	240	285												
10	26	50	90	130	175	224	276	330	385											
11	29	56	100	145	196	252	312	375	440	506										
12	32	62	110	160	217	280	348	420	495	572	650									
13	35	68	120	175	238	308	384	465	550	638	728	819								
14	38	74	130	190	259	336	420	510	605	704	806	910	1015							
15	41	80	140	205	280	364	456	555	660	770	884	1001	1120	1240						
16	44	86	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496					
17	47	92	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785				
18	50	98	170	250	343	448	564	690	825	968	1118	1274	1435	1600	1768	1938	2109			
19	53	104	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470		
20	56	110	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	
21	59	116	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2176	2397	2622	2850	3080	3311

The second line in the above table shows the number of balls in a triangular pile the base of which is the number in the same column in the top line. The other numbers show the contents of square and oblong piles, the bases of which are in the top line and in the left hand column respectively.

CHAPTER THIRD.

ARTILLERY CARRIAGES.

NOMENCLATURE.

The names of the wooden parts are arranged in the order of fabrication ; those of the iron parts, in the order in which they are put together.

There are *three field gun carriages*, viz : one for the 12-pounder gun, one for the 24-pounder howitzer, and one for the 6-pounder gun and the 12-pounder howitzer : the parts of all of them are similar, differing only in some of their dimensions.

The *limber* is the same for all the gun carriages and also for the caisson, forge, and battery wagon, with the slight exceptions indicated under the proper heads.

The *wheels* of all field carriages are of the same height and fitted to the same axletree arm, differing only in strength and weight, for the heavy and light carriages.

Field Gun Carriage.—Plate 3.

WOODEN PARTS.

- 1 *stock* ; the *head*, the *groove*, the *rounding of the trail*, the *trail*.
- 2 *dowels*, for the stock when made in two parts.
- 2 *cheeks* : the *trunnion-bed*, the *axle-notch*, the *top-rounding*.
- 1 *axle body* : the *groove* for the axletree.

IRON PARTS.

- 1 *lock-chain bolt*.
- 1 *eye plate* for lock chain.
- 1 *washer* and 1 *nut* for bolt.
- 1 *lock-chain* : the *links*, the *rings*, the *toggle*.
- 6 *rondelles*.
- 3 *assembling bolts*, for cheeks and stock.
- 3 *washers* and 3 *nuts* for do.
- 1 *washer-hook* for *lock-chain*, under the head of the middle assembling bolt.
- 2 *washer-hooks* for *handspikes*, at each end of the rear assembling bolt, fastened each by 1 *nail*.

- 2 handspike keys, with chains and staples.
- 2 trail handles.
- 2 bolts and 2 nuts for do.
- 2 trunnion plates.
- 2 chin bolts.
- 2 key bolts.
- 6 cheek bolts, with round heads.
- 26 nails, for trunnion plates.
- 1 axletree: the body, the stop, the shoulders, the arms, the linch-pin holes.
- 2 axle-bands, held by 3 nails.
- 2 under-straps.
- 2 bevel washers, for chin bolts.
- 4 washers and 10 nuts, for chin, key, and cheek bolts.
- 1 sponge hook, at the front end of the right under-strap.
- 1 sponge and worm-hook, on the left under-strap.
- 1 axle-strap, under the head of the stock, with an eye for the sponge bucket.
- 3 bolts and 3 nuts for axle-strap.
- 2 cap-squares.
- 2 eye pins riveted in the cap-squares.
- 2 cap-square chains, with 2 eye pins driven into the cheeks.
- 2 cap-square keys.
- 2 key chains.
- 2 eye pins for do.
- 1 trail lunette, fastened by 6 nails and the pointing-ring bolts.
- 1 trail plate, fastened to the stock by 6 nails, and to the lunette by 2 rivets.
- 1 large pointing ring, and 1 plate for do., connected together by a stud and bolt.
- 2 bolts, for pointing-ring plate, and 2 nuts for do.
- 1 small pointing-ring.
- 2 bolts and 2 nuts for do.
- 2 wheel-guard plates fastened to the sides of the stock, each by 5 nails.
- 2 prolonge hooks fastened to the upper side of the stock, each by 4 nails.
- 1 box for elevating screw, (brass.)
- 2 bolts, 2 nuts, and 2 washers, for do.
- 1 elevating screw: the screw, the handles, the head; the lower end of the screw riveted so that it cannot be removed without taking off the box.
- 2 handspike-rings fixed to the head of the cheeks, each by 2 clinched staples.
- 1 stop for sponge and rammer, fixed under the stock by 4 nails.
- 1 ear-plate, for supporting worm, fastened under the left side of the stock by 2 nails.

- 1 *key*, 1 *chain*, and 1 *eye pin*, for ear-plate.
- 1 *eye-plate* for *sponge chains*, fastened under the stock by 2 *nails*.
- 2 *hasps*, 2 *plates*, fastened to the sides of the stock, each by 2 *nails*, 2 *keys*, and 2 *chains*.
- 1 *linstock-socket*, fastened to the outer side of the right cheek by 6 *nails*.
- 2 *shoulder-washers*,
- 2 *linch-washers*,
- 2 *linch pins*,
- 2 *wheels*.

} for axletree.

Wheel.

WOODEN PARTS.

- 1 *nave*—14 *spokes*—7 *fellies*—7 *dowels*.

IRON PARTS.

- 4 *nave bands*, fastened each by 3 *nails*.
- 1 *tire*; 7 *tire bolts*; 7 *washers*, and 7 *nuts*.
- 1 *nave box*, fixed in the nave by *wedges*.

Limber.—Plate 4.

WOODEN PARTS:

- 1 *axle-body*—2 *hounds*—1 *fork*—1 *splinter-bar*.
- 4 *foot-board brackets*—2 *foot-boards*—1 *pole*—1 *pole prop*.

IRON PARTS.

- 4 *rivets* for the ends of *hounds*.
- 2 *bolts*, passing through the middle of the width of the hound into the axle body, for connecting the axle body and hounds.
- 2 *washers* for do.; 2 *nuts*, let into the axle body.
- 2 *bolts*, connecting the *hounds* and *splinter bar*; 4 *washers* and 2 *nuts* for do.
- 4 *axle bolts*, their heads countersunk into the upper side of the hounds.
- 1 *axletree*, let into the axle body.
- 2 *axle bands*.
- 2 *under straps*; 4 *nuts* for axle bolts.
- 1 *pintle hook*.
- 3 *bolts* for do.; 2 *washers*; 1 *stay* for *ammunition chest*, the foot fastened under the fork with 2 *nails*; 3 *nuts* for bolts.
- 1 *pintle-hook key*; 1 *chain* and 1 *staple* for do.

- 1 *tar-bucket hook*, fixed to the front of the axle body by 2 *nails*.
 - 2 *end bands for splinter bar*, each fastened by 1 *rivet*.
 - 1 *eye-plate for pole-prop socket*.
 - 2 *middle bands for splinter bar*.
 - 2 *bolts for splinter bar and fork*; 1 *fork strap*; 2 *nuts*.
 - 4 *trace hooks*.
 - 1 *pole-prop socket*, fastened by 1 *rivet*.
 - 1 *pole-prop ferrule*, fastened by 1 *rivet*.
 - 1 *pole-prop chain*, one end fixed to an *eye pin* riveted on a *burr* on the upper side of the splinter bar; the other end having a *hook*.
 - 2 *stay pins*, for ammunition chest.
 - 4 *plates for do.*, fixed to the upper and under sides of the hounds, each by 2 *nails*.
 - 2 *spring keys for do.*
 - 1 *pole rivet*, for the large end of the pole; 1 *burr* for do.
 - 1 *pole-bolt*; 2 *washers* and 1 *nut* for do.
 - 1 *muff for pole yoke*; 1 *washer*, and 1 *key* for do.
 - 1 *pole-strap ring*, fastened by 2 *rivets*.
 - 2 *pole-chains*: 9 *links* and a *cold shut ring*.
 - 1 *collar for pole yoke*.
 - 2 *branches for do.*
 - 2 *sliding rings for do.*
 - 2 *bolts* and 2 *nuts* for do.
 - 2 *shoulder washers*,
 - 2 *linch washers*,
 - 2 *linch pins*,
 - 2 *wheels*,
- } the same as for the gun carriage.

Ammunition Chest.

WOODEN PARTS.

- 2 *ends*—2 *sides*—1 *principal partition*.
- 1 *bottom*—1 *cover*: the *frame*, the *pannel*, and the *lining*.

IRON PARTS.

- 4 *corner plates* for the ends and sides, held each by 14 *wood screws*, $\frac{3}{4}$ -in No. 12.
- 1 *assembling bolt*; 1 *washer plate* held by 2 *wood screws*, $\frac{3}{4}$ -in. No. 12.
- 1 *back strap*, held by 6 *wood screws*, $\frac{3}{4}$ -in. No. 12, and by the *assembling bolt*.

1 *nut* for assembling bolt ; 2 *front straps*, each held by 2 *rivets* and 4 *screws*, $\frac{3}{4}$ -in. No. 12.

1 *corner plate*, fixed at the middle of the front and bottom by 14 *wood screws*.

2 *hinges*, fastened to the box each by 5 *wood screws* and 1 *rivet* ; to the cover, by 4 *wood screws* and 2 *rivets*.

1 *hasp*, fastened to the cover by 5 *wood screws* and 1 *rivet*.

1 *turnbuckle*, riveted on the end of the assembling bolt.

1 *hasp-plate*, fastened to the cover by 3 *screws*.

1 *covering*, (sheet copper,) fastened by 216 *tacks*.

2 *handles*, fastened each by 4 *rivets*.

Caisson.—Plate 4.

WOODEN PARTS.

1 *middle rail*—2 *side rails*—1 *cross bar*—1 *foot-board bracket*—2 *foot boards*—1 *axle body*—1 *stock*.

IRON PARTS.

1 *middle assembling bar*, with stays for ammunition chests.

2 *bolts* ; 2 *washers* and 2 *nuts* for do.

1 *hook*, at the end of the middle rail ; for a carriage which has lost its limber.

1 *rear assembling bar* for supporting spare wheel axle, with a hole for a pick-axe ; fastened to the side rails by 2 *bolts* ; 2 *washers* and 2 *nuts* for do.

1 *bridle for the end of middle rail*, fastened by 4 *nails*.

1 *spare wheel axle* : the *body*, the *shoulder washer*, the *spindle* ; 3 *rivets* for connecting the parts of the body.

1 *chain* and *toggle* for do.

2 *stay bolts* for do.

1 *connecting bolt* and 1 *nut* for do.

2 *nuts* for stay bolts.

1 *foot bolt*, to connect the spare wheel axle with the middle rail, and to secure the carriage hook ; 1 *nut* for do.

3 *foot-board bolts*.

1 *lock-chain bridle*, under the front end of the left rail.

1 *lock chain* : the *links*, the *rings*, the *toggle*.

1 *washer* and 3 *nuts*, for foot-board bolts.

1 *lock-chain hook*, fixed to the rail by 1 *rivet*.

4 *axle bolts*, countersunk in the upper side of the rails.

1 *axletree*, set into the axle body.

- 2 *axle bands*, on the ends of the wooden body.
 - 2 *under straps* ; 4 *nuts* for axle bolts.
 - 1 *stock rivet*, between the lunette bolts ; 1 *burr* for do.
 - 1 *lunette*, fastened by 12 *nails* and 2 *bolts*.
 - 1 *key plate* for spare pole.
 - 1 *key*, 1 *chain*, and 1 *staple* for do.
 - 2 *lunette bolts*, and 2 *nuts*.
 - 2 *wheel guard plates*, fastened each by 5 *nails*.
 - 2 *stock stirrup bolts*, the heads on the front foot board.
 - 1 *stock stirrup* ; 2 *nuts* for stirrup bolts.
 - 3 *axle-strap bolts*, one connecting the middle assembling bar with the middle rail.
 - 1 *strap for axletree and stock*.
 - 1 *spare-pole ring*.
 - 3 *nuts* for axle strap bolts.
 - 4 *stay pins*, for ammunition chests ; 8 *washer plates* for do., fixed each by 2 *nails* ; 4 *spring keys* for do.
 - 1 *handspike ring*, on the right side of the middle rail ; 2 *washers* and 1 *nut* for do.
 - 1 *key plate for handspike*, fixed by 2 *nails* to the right side of the middle rail.
 - 1 *key*, 1 *chain*, and 1 *staple* for do.
 - 2 *staples for tool handles*, on the axle body ; that for the pick, on the left side of the middle rail ; that for the shovel, near the right hand rail.
 - 1 *key plate for shovel*, fixed by 2 *nails* to the inner side of the right hand rail.
 - 1 *key*, 1 *chain*, and 1 *staple* for do.
 - 1 *ring and staple* for the axe handle, on the outer side of the left hand rail ; 1 *key plate for axe blade* ; 1 *bolt*, 1 *washer*, and 1 *nut* for do. ; 1 *key* and *chain* for do.
 - 2 *shoulder washers*,
 - 2 *linch washers*,
 - 2 *linch pins*,
 - 2 *wheels*,
 - 2 *ammunition chests*,
- } like those on the gun carriage and limber.

Travelling Forge.—Plate 5.

Body.

WOODEN PARTS.

- 2 *side rails*—4 *cross bars*, fastened with wooden *pins*—1 *middle rail*—1 *axle body*—1 *stock*—8 *studs* for the sides of bellows house, fastened by wooden *pins*—

2 plates—4 girders, to support the bellows—2 end boards—2 bows, fastened to the plate, each by 2 wood screws—2 bottom boards, fastened by 54 clout nails—8 side boards, fastened by 96 clout nails—7 roof boards, fastened by 84 screws.

IRON PARTS.

- 1 axletree ; 2 axle bands, each fastened by 3 nails.
- 4 axle bolts ; 2 under straps ; 4 nuts for axle bolts.
- 1 stock rivet and burr ; 1 lunette, fastened by 12 nails and 2 bolts ; 2 nuts for lunette bolts.
- 2 stock stirrups ; 4 bolts and 4 nuts, for do.
- 1 axle and stock strap : 3 bolts and 3 nuts for do.
- 2 wheel guard plates, fastened by 5 nails.
- 2 key plates, fastened to the rear stud by 4 rivets.
- 2 keys, for coal box ; 2 chains and 2 staples for do. ; 1 staple and 1 hook, for carrying the bellows pole when not in use.
- 1 support of the bellows pole, fastened by 2 nails and 2 rivets.
- 1 roof cover, (sheet copper,) fastened by 300 tacks.
- 1 fire place : (boiler iron,) the back, the sides, the front, the bottom, joined together by 56 rivets, and fastened in place by 30 nails ; 1 air back for do., (cast iron,) fastened to the back of the fire place by 4 bolts and 4 nuts.

Bellows.—(Square.)

WOODEN PARTS.

- 3 planks, (poplar,)—2 cross heads, (poplar,) fastened to the ends of the middle plank, each by 10 screws.
- 2 valves, (cherry,) cushioned with leather which forms also the hinge : it is fastened to the valve by 20 copper tacks, and to the lower plank by 10 clout nails.
- 2 ribs—1 bellows pole, (ash.)

IRON PARTS:

- 4 hinges, fastening the upper and lower planks to the cross heads ; 6 wood screws for each hinge.
- 2 bellows arms, fastened to the middle plank, each by 2 rivets and 5 screws.
- 1 hook, fastened to the lower plank by 2 rivets and 3 screws ; 1 chain, (2 links ;) 1 eye strap, fastened to the pole by 4 rivets.
- 1 windpipe, (copper,) fastened by 12 copper tacks.
- The leather, fastened to the planks by 800 bellows nails, and to the ribs by 120 bellows nails.

Coal Box.**WOODEN PARTS.**

2 ends—2 sides—1 bottom—1 cover—2 cover brackets, fastened by 8 screws.

IRON PARTS.

4 corner straps, for the ends and sides, fastened each by 6 screws.

2 end straps, fastened to the front by 3 screws each, and to the ends by 1 rivet and 5 screws. These straps, with the key plate, serve to fasten the coal box to the rear of the carriage.

2 handles, with tapped stems; 4 washers and 4 nuts for do.

2 Thinges, fastened to the box by 5 screws, and to the cover by 1 rivet and 4 screws each.

1 hasp, fastened by 1 rivet and 4 screws.

1 turnbuckle and plate, fastened by 2 rivets.

1 cover, (sheet copper,) fastened by 150 tacks.

Water Bucket.

10 staves, (oak)—2 ears, (iron,) fastened each by 2 rivets.

1 handle, (iron)—3 hoops, (iron,) fastened each by 2 rivets.

Wheels and Limber.

The same as for the gun carriage, omitting the *principal partition* and the *assembling bolt* of the limber box.

Battery Wagon.—Plate 6.

For carrying tools, implements, equipments, and stores required for the current service of a battery in the field.

Body.**WOODEN PARTS.**

2 bottom rails—5 cross-bars—3 bottom boards, fastened by 35 nails—1 axle body—2 boards for the sides, fastened each by 6 rivets and burrs—2 upper rails—2 end boards, fastened each by 3 rivets—1 stock.

IRON PARTS.

8 studs, for the sides.

1 spare stock hook, on the rear stud of the right side; to carry a spare stock for the wagon.

2 assembling bolts; 2 nuts for do.

3 bolts for the middle studs; 1 turnbuckle bolt; 4 washers and nuts for do.

2 rivets and burrs, for the bottom rails.

4 grooves for the wagon ends.

1 turnbuckle for spare stock hook ; 1 rivet-bolt for do.

11 bolts for grooves ; 11 nuts for do.

1 spare stock stirrup, on the front stud of the right side.

12 rivets and burrs, for the sides ; 2 rivets and burrs, for the upper rails and studs.

1 hook for cover strap ; 1 eye staple for hasp ; 2 burrs for do. ; the hook and eye staple are riveted against the inside of the left upper rail, their stems passing through the middle studs.

2 side stays for the rails, fastened to the ends of the upper rails, each by 2 wood screws.

2 end studs, in the centre of the end boards ; 1 bolt for the front end stud ; 1 nut for do. ; 1 washer and 1 nut for the tapped shank of the rear end stud.

4 under-strap bolts ; 1 axletree ; 1 mortice plate, for the front of the axle body, fastened by 8 screws ; 2 understraps ; 4 nuts, for understrap bolts.

1 stock rivet and burr ; 1 lunette, fastened by 12 nails and 2 bolts ; 2 nuts for lunette bolts ; 2 wheel-guard plates, fastened by 5 nails each.

2 bolts for stock stirrup, their heads countersunk in the front cross bar ; 1 stock stirrup ; 2 nuts for bolts ; 2 bolts for the stock and cross bars, heads countersunk in the bottom boards ; 2 washers and 2 nuts for do.

1 bolt for the front end of the right bottom rail ; 1 washer and 1 nut for do. ; 2 bolts for left rail, fastening the lock-chain bridle ; 1 lock-chain bridle ; 1 lock chain ; 2 nuts for the bolts of the left bottom rail ; 1 lock-chain hook, fastened to the left rail by 1 rivet.

Forage Rack.

WOODEN PARTS.

2 sides—3 bars, fastened by wooden pins.

IRON PARTS.

2 bands, fastened each by 2 rivets and 10 screws ; 2 oval washers, fastened each by 2 screws ; 2 bolts ; 4 washers, and 2 nuts for do. ; 2 forage-rack chains.

Wagon Cover.

WOODEN PARTS.

2 side rails—2 end rails—1 ridge pole—2 studs—2 cover ends, fastened by 7 screws—9 cover boards, fastened to the end bows by 36 rivets, and to the middle bows by 36 screws.

IRON PARTS.

4 *corner squares*, fixed to the inner angles of the cover, each by 2 *rivets* and 2 *wood screws*.

4 *bows*, each fastened to the ridge pole by 1 *rivet*, and the front and rear bows to the end studs each by 1 *rivet*.

4 *bolts*, fastening the end bows to the rails; 4 *nuts* for do.

4 *rivets* for the ends of middle bows, 2 in the right rail, and 2 in the plates for the hasp and cover strap; 2 *plates* and *staples* for the hasp and cover strap; 2 *wood screws* for do.; 1 *hasp*; 1 *cover strap*; 3 *hinges*, fastened to the right upper rail of the wagon body by 6 *bolts*, to the cover rail by 6 *rivets*; 6 *nuts* for hinge bolts.

Top covering, painted canvass, fastened by 264 *clout nails*.

Wheel.

The same as for the gun carriage.

Limber.

The same as for the gun carriage, except that in the chest a *plate* and *staple* for a padlock are substituted for the assembling bolt and turnbuckle; and the principal partition is placed parallel to the sides.

Water Bucket.

The same as for the forge.

Mountain Howitzer Carriage.

Body.

WOODEN PARTS.

1 *stock*, in two pieces if necessary—1 *axletree*, notched into the stock.

IRON PARTS.

2 *dowels*; 3 *assembling bolts*; 6 *washers* and 3 *nuts* for do.

2 *trunnion plates*, fastened each by 3 *bolts* and 6 *nails*; 2 *key bolts*.

2 *chin bolts*; 2 *round-headed bolts*.

1 *axle skein*, countersunk in the axletree, and fastened to each arm by 4 *nails*.

2 *axle bands*, fastened at the shoulder of the axletree each by 3 *nails*.

2 *ferrules* for the ends of the axletree, countersunk and fastened each by 1 *rivet*; 2 *shoulder plates*, countersunk in the upper side of the arms and fastened each by 2 *nails* in the shoulder of the axletree; 2 *axle straps*; 6 *nuts* for bolts.

2 *cap squares* ; 2 *cap-square keys* ; 2 *chains*, each of 3 *links* and 1 *ring*, held by 1 *staple*.

1 *trail plate*, fastened by 10 *nails* and 4 *rivets*.

1 *box for elevating screw*, (brass,) fastened by 1 *bolt* ; 1 *washer* and 1 *nut* for do.

1 *elevating screw*.

4 *implement hooks* ; 2 of them fastened in the rear of the second assembling bolt, each by 1 *wood screw* ; the other 2 near the head of the stock, each fastened by 2 *wood screws*.

2 *linch pins*.

Wheel.

WOODEN PARTS.

1 *nave*—12 *spokes*—6 *fellies*—6 *dowels*.

IRON PARTS.

2 *nave bands* ; 6 *clout nails* ; 1 *tire*, fastened by 12 *nails* ; 2 *nave boxes*, (cast iron,) fastened each by 4 *pins* 1 inch long.

This carriage, being intended for use in countries where wheel carriages cannot generally travel, is not provided with a limber. The howitzer and its carriage and ammunition are usually transported on pack horses. When circumstances permit, they may be transported in a wagon or cart, or temporary shafts may be adapted to the trail of the carriage.

Siege Gun Carriage.—Plate 7.

Body.

WOODEN PARTS.

1 *stock*, in 2 pieces—2 *dowels* for do.—2 *cheeks*—1 *axle body*—1 *breech bolster*, for supporting the piece in its travelling position.

IRON PARTS.

1 *stock assembling bolt* ; 2 *washers* and 1 *nut* for do. ; 1 *manœuvring bolt* ; 2 *collars* for do. ; 4 *washers* and 2 *nuts* for do.

6 *assembling rondelles*, (cast iron;) the two in the rear have tenons let into the stock and cheeks ; 2 *assembling bolts* for the head of the carriage ; 4 *washers* and 2 *nuts* for do. ; 1 *assembling eye bolt* ; 1 *lock-chain ring* ; 2 *washers* and 1 *nut* for do.

1 *lock chain* ; the long branch consists of two parts, one composed of 7 *links* and 2 *rings*, the other of 5 *links* and 2 *rings*, which are connected by a rope

$\frac{1}{2}$ inch thick passed several times through the rings so as to form a rope $1\frac{1}{2}$ inch thick and 12 inches long; the short branch consists of 3 *links*, 3 *rings*, and 1 *toggle*.

2 *trunnion plates*; 2 *chin bolts*; 4 *cheek bolts*; 2 *washers* and 2 *nuts* for do.; 2 *travelling trunnion bolts*, to support the trunnions when the gun is in its travelling position; 2 *washers* and 2 *nuts* for do.; 2 *key bolts*.

1 *axletree*.

2 *understraps*; 2 *bevel washers* for chin bolts; 6 *nuts* for bolts passing through the understraps; 2 *bolts for the head of the stock*, the heads countersunk in the upper side of the stock; 1 *axle strap*; 2 *nuts* for axle strap and stock bolts.

2 *axle bands* fastened by 4 *nails* each.

1 *lock-chain hook*; 2 *washers* and 1 *nut* for do.

2 *cap squares*; 4 *eye pins* for do.; 2 *cap-square chains*; 2 *cap-square keys*; 2 *chains and staples* for do.

1 *box*, (brass,) for *elevating screw*; 2 *bolts*; 2 *washers* and 2 *nuts* for do.; 1 *elevating screw*; 2 *wheel-guard plates*, fastened each by 6 *nails*.

2 *breech-bolster bolts*, their heads countersunk in the bolster; 2 *washers* and 2 *nuts* for do.

1 *lunette plate*, its *rondelle* fixed to it by 8 *rivets*. The lunette is fastened under the stock by 2 *nails* and 2 *bolts*; 2 *washers* and 2 *nuts* for lunette bolts.

1 *trail plate*, fastened by 29 *nails*.

2 *axle-shoulder washers*; 2 *linch washers*; 2 *linch pins*.

Wheel.

WOODEN PARTS.

1 *nave*—14 *spokes*—7 *fellies*—7 *dowels*.

IRON PARTS.

2 *brow bands* and 2 *end bands*, each fastened by 3 *nails*.

1 *tire*; 7 *tire bolts*; 7 *washers* and 7 *nuts* for do.

1 *nave box*, (brass.)

Limber.

WOODEN PARTS.

1 *fork and saddle*—2 *hounds*—1 *splinter bar*—1 *pole*—1 *double tree*.

IRON PARTS.

2 *rivets and burrs*, for the front end of the hounds.

1 *bolt* for the head of the fork saddle; 2 *washers* and 1 *nut* for do.

- 1 *axletree*, let into the under side of the saddle and hounds.
- 1 *saddle plate*, fastened by 7 *nails* and by the bolts of the double axle strap.
- 1 *sweep bar*; 2 *ear bolts*; 2 *washers* and 2 *nuts* for do.
- 1 *double axle strap*, the rear end terminating in an eye for the lashing chain;
- 1 *lashing chain*; 4 *rings* and 1 *hook*: one ring is welded into the eye of the axle strap, and another into the hook.
- 6 *bolts* for the axle strap; 6 *nuts* for do.
- 2 *understraps*; 4 *bolts* for do., 2 through the ends of the sweep bar, and 2 through the hounds; 4 *nuts* for do.
- 1 *pintle*; 1 *nut* for do.
- 2 *end bands* for splinter bar, fastened each by 1 *rivet*; 2 *middle bands* for do.; 4 *trace hooks*; 1 *bridle for the end of the fork*; 4 *splinter-bar bolts*, 2 through the fork and 2 through the hounds; 2 *washers* and 4 *nuts* for do.; 1 *fork bridle*, fastened by 4 *nails*.
- 1 *pole rivet and burr*.
- 1 *eye staple* for the end of the pole; 1 *ferrule*, at the end of the pole; 1 *pole band*; 1 *key* for do.; 3 *bolts* for the eye staple; 5 *washers* and 3 *nuts* for do.; 2 *pole chains*, each consisting of 1 *ring*, 1 *S*, and 9 *links*.
- 2 *bolts* for the rear end of the pole; 4 *washers* and 2 *nuts* for do.
- 1 *middle band* for the double tree, fastened by 2 *rivets*; 1 *pole hook*; 1 *double trace hook*; 2 *end bands* for double tree, fastened each by 1 *rivet*; 2 *trace hooks*.
- Shoulder and linch washers*,
- Linch pins*,
- Wheel*,

as for the gun carriage.

GARRISON AND SEA COAST CARRIAGES.

The carriages for cannon of different calibres vary from each other only in their dimensions, except in a few particulars mentioned under the proper heads.

Casemate Carriage.—Plate 8.

Top Carriage.

WOODEN PARTS.

2 cheeks; each composed of 2 pieces notched together—1 front transom—1 trail transom—1 axletree—2 guides—1 roller.

IRON PARTS.

2 trail handles, with the feet let in flush with the cheeks—2 friction rollers, (brass,)—2 boxes for do., fastened by 8 screws—8 axle skeins, fastened by 16 nails—2 shoulder plates, fastened by 10 nails—2 axle bands, fastened by 10 nails.

8 roller skeins, fastened by 16 nails—2 roller bands, fastened by 10 nails.

4 assembling bolts; 2 through each transom—4 washers and 4 nuts for do.

2 trunnion plates, let into the cheeks and held each by 3 bolts—2 axle straps, let into the cheeks—2 roller plates do.—2 roller straps.

12 cheek bolts—4 washers and 12 nuts for do.; 6 of these bolts pass through the trunnion plates; 4 of them, through the axle straps; and 4 of them through the roller straps—4 guide bolts—4 washers, and 4 nuts for do.

2 truck wheels, (cast iron)—2 linch pins.

In cypress carriages, add: 8 cheek plates for the handspikes to rest on in raising the gun, held by 24 nails.

When an elevating machine is attached to the carriage, add: 1 pointing plate bolt—2 washers and 1 nut for do.

Chassis.

WOODEN PARTS.

2 rails—2 counter hurters—1 front transom—1 rear transom—1 tongue 1 prop, fastened by 2 pins 0.6 inch thick.

IRON PARTS.

2 rear transom and rail bolts, countersunk in the upper side of the transom; 2 washers and 2 nuts for do.—4 tongue bolts; 2 double washers and 4 nuts for do.—2 tongue plates fastened by 16 screws—1 tongue and transom strap, let into the upper side of the front transom and tongue—2 front transom and rail bolts; 2 nuts for do.—1 tongue fork, let into the front end of the wooden

tongue, on the under side, and held by the two bolts which pass through the front transom and tongue—1 *front transom and tongue bolt*; 1 *washer* and 1 *nut* for do.—1 *bolt* for transom and tongue strap; 1 *washer* and 1 *nut* for do.—2 *rail plates*, fastened by 8 *screws* and 54 *nails*—1 *rear transom and tongue brace*; 2 *bolts* and 2 *nuts* for do.

8 *boxes* (brass) for the journals of the traverse wheels, held by 16 *screws*—8 *caps* for do., held by the same screws.

2 *counter hurter and rail bolts*: 2 *washers* and 2 *nuts* for do.

4 *traverse wheels*, (cast iron, with wrought iron journals); 1 *tongue*; 2 *bolts* and 2 *nuts* for do., connecting the tongue with the fork.

1 *pintle*, (cast iron,) 3.95 inches diameter.

Cast Iron Carriages.

Some top carriages for casemate service have been made of *cast iron*, consisting of 2 *cheeks* connected together by *bolts*; with a *wooden axletree*.

Barbette Carriage.—Plate 9.

Top Carriage.

WOODEN PARTS.

2 *cheeks*, each composed of 1 *upright* and 1 *brace*—1 *front transom*—1 *middle transom*—1 *trail transom*—1 *transom-and-axle tie*—1 *elevating bed*—1 *axle body*.

IRON PARTS.

2 *trail rivet-bolts* and 2 *nuts* in the lower ends of the braces—2 *cheek bolts*—2 *flat washers*—2 *bevel washers*, (cast iron,) and 2 *nuts* for do.—1 *lunette*, let into the under side of the transom and axle tie.

4 *assembling bolts*; 2 through the front transom, and 1 through each of the others—8 *washers* and 4 *nuts* for do.

4 *tie bolts*; 1 through the middle transom, 1 through the elevating bed and the box of the elevating screw; 1 through the trail transom; and 1 through the trail transom and the box of the elevating screw.

1 *box for the elevating screw*, (brass)—4 *nuts*—1 *elevating screw*.

1 *axletree*, let into the axle body—2 *axle stirrups*—2 *bridles* and 4 *nuts* for do.

1 *clamp washer*, fastened by 2 *axle and tie bolts*—1 *double washer* and 2 *nuts* for do.

2 *collars* for manœuvring bolts—2 *manœuvring bolts*, connecting the axle body with the uprights of the cheeks—6 *washers* and 2 *nuts* for do.—2 *manœuvring staples*, on the under side of the braces.

2 *shoulder washers*, let into the end of the axle body—2 *linch washers*—2 *linch pins*.

For calibres above a 24-pdr., the carriage requires in addition to the above: 2 *assembling bolts*, 1 through the middle, and 1 through the rear transom—4 *washers* and 2 *nuts* for do.

For the 8-in. sea coast howitzer, add also: 1 *bolt*, for the box of the elevating screw which is brought forward and placed across the elevating bed—1 *washer* and 1 *nut* for do.

In other respects the carriage is the same as for the 32-pdr. gun.

Wheel.

WOODEN PARTS.

10 *spokes*.

IRON PARTS.

1 *nave*, (cast iron)—1 *flanged roller*, (cast iron)—1 *tire*—10 *tire nails*.

Chassis.

WOODEN PARTS.

2 *rails*—2 *hurters*—2 *counter hurters*—1 *front transom*—1 *middle transom*—1 *rear transom*—1 *tongue*—1 *prop*.

IRON PARTS.

4 *rivets and burrs*, for hurters and counter hurters—8 *wood screws* and 8 *nails* for do.—4 *rivets and burrs* for front transom—2 *rivets and burrs* for middle transom—1 *friction plate*, let in flush with the lower side of the front transom, and held by 10 *nails* and by the front transom and rail bolts.

2 *hurter and rail bolts*—4 *washers* and 2 *nuts* for do.

2 *front transom and rail bolts*, the heads countersunk flush with the upper surfaces of the hurters—2 *washers* and 2 *nuts* for do.

2 *middle transom and rail bolts*, the heads countersunk in the upper washers—4 *washers* and 2 *nuts* for do.; the upper washers flush with the rails.

4 *counter hurter and rail bolts*; the heads flush with the upper surface of the counter hurter.

2 *fork sockets*, let into the rails.

2 *fork plates*, fastened to the under side of the rails and rear transom, each by 6 *nails* and 3 *bolts*, 2 of which are the counter hurter and rail bolts.

2 *transom and fork plate bolts*; the heads countersunk in the upper side of the rear transom—6 *nuts*—1 *manœuvring loop*, at the rear end of the tongue; the upper branch let in flush with the notch in the tongue, and held by 2 *nails*; the lower branch held by 1 *rivet*, the head countersunk in the tongue.

1 *front transom and tongue bolt*; the head placed in the bottom of the pintle hole—1 *washer* and 1 *nut* for do.—1 *middle transom and tongue bolt*; 1 *rear transom and tongue bolt*; the heads flush with the upper side of the tongue—2 *washers* and 2 *nuts* for do.

2 *traverse wheels*, (cast iron,)—2 *forks* for do.

2 *fork bolts*—2 *nuts* for do.

2 *plates* for props, fastened by 4 *nails*—1 *prop bolt*—1 *key* for do.

For calibres above 24-pdr., add:

1 *tongue brace*, welded to the friction plate, and fastened to the tongue by 1 *bolt*—1 *washer* and 1 *nut* for do.

Pintle Cross.

WOODEN PARTS.

2 *cross pieces*—1 *pintle bolster*, fastened to the cross by 4 *octagonal wooden pins* 1 inch thick.

IRON PARTS.

1 *bolster plate*, (cast iron;) fastened to the bolster by 4 *bolts*—4 *washers* and 4 *nuts* for do.

1 *pintle*—1 *washer* and 1 *key* for do.

In temporary batteries, a circular platform of plank is required for the wheels of the chassis to traverse on. In permanent batteries, the bolster plate, the pintle and the traversing circle are fixed in masonry.

Mortar Carriage.

WOODEN PARTS.

2 *cheeks*, each composed of two pieces notched together and joined by 3 *dowels*—3 *transoms*.

IRON PARTS.

4 *cheek bolts*—6 *washers* and 4 *nuts* for do.; the heads of the rear bolts are countersunk in the under side of the cheeks.

2 *plates for axle notches*,
2 *trunnion plates*, } countersunk in the cheeks.

4 *key bolts*.

2 *axletrees*, one under each cheek.

- 2 *axle straps*—4 *bevel washers* and 4 *nuts* for key bolts.
 - 6 *assembling bolts*, 2 through each transom; those in the trail transom serve for manœuvring bolts—12 *washers* and 6 *nuts* for do.
 - 2 *cap squares*—4 *cap-square keys*—4 *chains* for do., fastened to 4 *eye pins* riveted in the cap squares.
 - 1 *box for elevating screw*, turning in 2 *strap sockets* fixed to the heads of the cheeks, each fastened by 3 *nails* and 2 *bolts*—4 *nuts* for the bolts.
 - 1 *bridle for elevating screw*; composed of 2 branches fastened to the cheeks by 2 *bolts*—4 *washers* and 2 *nuts* for do.
 - 1 *elevating screw*—1 *bolt* for securing the bridle to the head of the elevating screw—1 *nut* for do.
 - 4 *shoulder washers*—4 *linch washers*—4 *linch pins*.
 - 4 *truck wheels*, (cast iron.)
- This carriage has been made only for the 10-in. heavy mortar with cylindrical chamber. Its weight is 2,112 lbs.

Mortar Bed.

A mortar bed consists of 2 *cheeks*, (cast iron,) and 2 *transoms*, (wood,)—the cheeks are connected by 2 *manœuvring bolts*, and from 2 to 4 *assembling bolts*, according to the size of the bed.

G I N S.

Siege and Garrison Gin.

WOODEN PARTS.

- 2 *legs*—1 *pry pole*—3 *cross bars*—6 *pins*—1 *windlass*.

IRON PARTS.

6 *rivets* for the ends of cross bars—6 *burrs* for do.—1 *tongue*—2 *guard plates*; one of the guard plates is fastened to the tongue by 3 *rivets*, the other is fastened to the inner face of the right leg by 2 *rivets* and 1 *nail*; the tongue is fastened to the inner face of the left leg by 2 *rivets* and 1 *nail*—2 *head straps* for the legs, each fastened by 2 *nails* and 8 *wood screws*.

1 *assembling bolt*—2 *bevel washers*, each held by the 2 upper rivets of the guard plates—1 *nut*, with a handle—2 *sheaves* (brass)—1 *sheave bolt*—2 *oval washers*, each fastened by 2 *wood screws*—1 *key* for sheave bolt—1 *key bolt* for pry pole—1 *chain* composed of 1 *staple*, 2 *rings* and 11 *links*—2 *boxes* for gudgeons of windlass, the axle hole lined with a copper ring 0.2 inch thick—8 *bolts*, 8 *washers*, and 8 *nuts* for do.

- 2 *journals* for windlass, fastened each by 1 *pin*.

- 4 *windlass bands*, fastened by 2 *nails* each.

2 *leg bands*, each fastened by 2 *nails*.

2 *points* for the legs, driven into the lower ends.

1 *step bolt*—2 *washers* and 1 *nut* for do.; in the right leg above the upper cross bar.

1 *pry-pole band*, fastened to the foot of the pry pole by 2 *nails*—1 *point* for pry pole—1 *handle* for do., fastened by 2 *pins*; 2 *washers* for do., fastened each by 3 *nails*.

1 *pry-pole tongue*, let into the top of the pry pole and held by 2 *rivets* with *burrs*—2 *bands* for do., each held by 2 *nails*.

1 *strap* for pulley block (detached)—1 *hook*, 1 *sheave bolt*, 1 *key* for do.

Casemate Gin.

WOODEN PARTS.

2 *legs*—1 *pry pole*—7 *cleats* for do.—1 *windlass*.

IRON PARTS.

2 *middle bands* for legs, each fastened by 3 *nails*.

2 *upper bands*, each fastened by 2 *nails*.

2 *lower bands*, each fastened by 3 *nails*—2 *plates* and *points*, each fastened by 4 *nails*.

2 *boxes* (brass) for gudgeons of windlass—2 *box plates*, each fastened by 4 *nails*.

8 *washers*, for bolt holes in legs, each fastened by 4 *nails*.

2 *pauls*—2 *bolts*, 4 *washers* and 2 *nuts* for do.

2 *cross bars*—4 *bolts* and 4 *keys* for do.

1 *upper band* for pry pole, fastened by 2 *nails*

1 *lower band* for do., fastened by 2 *nails*—1 *plate* and *point* for do., fastened by 4 *nails*.

3 *nails* for each cleat.

1 *pry-pole handle*—2 *washers* for do., each fastened by 2 *nails*.

4 *square bands* for windlass, each fastened by 4 *nails*—2 *round bands* for do.

2 *gudgeons*.

2 *ratchet wheels*, (cast iron,) each fastened by 4 *nails*.

1 *clevis*—1 *bolt* and 2 *keys* for do.

2 *key chains* and *staples*.

Rampart Gin,

Differs from the casemate gin only in its dimensions.

PRINCIPAL DIMENSIONS AND WEIGHTS OF CARRIAGES.

FIELD AND SIEGE GUN CARRIAGES.		Field 12-pdr.	Light artillery 6-pdr.	Mountain howitzer.	Siege 24-pdr.
		In.	In.	In.	In.
Distance between the inside of the trunnion plates - - - - -		12.1	9.55	7.	18.2
Diameter of the trunnion holes - - - - -		4.62	3.67	2.7	5.83
Depth of the centre of trunnion hole below the upper face of the cap square in rear of the trunnion - - - - -		0.65	0.25	0.5	2.
Distance between the points of contact of the trail and wheels with the ground line - - - - -		81.	71.	43.72	102.
Distance of the centre of trunnions in rear of the centre of the axletree, the piece being in battery on horizontal ground - - - - -		0.5	0.35	2.9	2.8
Distance from the axis of the trunnions to that of the axletree - - - - -		13.4	14.84	9.	23.1
Height of the axis of the piece above the ground - - - - -		41.8	43.34	27.3	52.1
Distance from the front of the wheels to the end of the trail - - - - -		124.7	112.4	69.75	143.
Distance between the centres of the axletrees of the gun carriage and limber - - - - -		103.25	92.75	-	95.25
VERTICAL FIELD OF FIRE.	} above the horizontal line - - - - -	10°	11°	12°	12°
	} below the horizontal line - - - - -	9°	6°	6°	4°
Whole length of the axletree - - - - -		75.25	79.25	37.8	81.8
Track of the wheels - - - - -		60.	60.	28.32	60.
WHEELS.	{ Height - - - - -	57.	57.	38.	60.
	{ Dish of finished wheel - - - - -	1.5	1.5	1.	2.
	{ Number of spokes - - - - -	14.	14.	12.	14.
		lbs.	lbs.	lbs.	lbs.
WEIGHT	{ of gun carriage, without wheels - - - - -	687	445	134	1,600
	{ of limber, without wheels or ammunition chest - - - - -	333	276	-	520
	{ of ammunition chest - - - - -	128	105	-	-
	{ of one wheel - - - - -	194	164	54	370
	{ of carriage and limber complete, without implements - - - - -	1,924	1,482	242	3,600

OTHER FIELD CARRIAGES.		LIGHT ARTILLERY.			
	Forge. Model of 1840.	Caisson.	Forge.	Battery wagon.	
	In.	In.	In.	In.	
Distance between the axletrees	112	89.5	91.0	111.6	
	lbs.	lbs.	lbs.	lbs.	
Weight of the limber	333	276	276	276	
Weight of the body	826	418	614	876	
Weight of the carriage and limber complete, without implements	2,120	1,665	1,709	1,913	

INTERIOR DIMENSIONS AND WEIGHTS.		Length.	Width.	Height.	Weight.
		In.	In.	In.	lbs.
Ammunition chest		40.	18.	14.6	128
Coal box for the forge,	Model of 1840	32.2	15.15	19.25	80
	Light artillery	30.	12.25	15.25	58
Battery wagon body		97.	36.	22.	

DIMENSIONS AND WEIGHTS OF GINS.

	Length of legs.	Length of roller.	Weight.	Remarks.
	In.	In.	lbs.	
Siege and garrison	174	62	482	} Spruce. Yellow pine.
Casemate	168	91	772	
Rampart	252	94	1200	
Single block for siege gin			42	
Double block for casemate or rampart gin			75	

DIMENSIONS AND WEIGHTS OF GARRISON AND SEA-COAST CARRIAGES.

	CASEMATE.			BARBETTE.		
	42	32	24	42	32	24
	In.	In.	In.	In.	In.	In.
Distance between the inside of the trunnion plates or cheeks	-	-	-	22.1	20.75	18.1
Diameter of the trunnion holes	-	-	-	7.0	6.4	5.82
Depth of centre of trunnion holes below the upper face of the cap square or cheek, in rear of the trunnions	-	-	-	0.75	0.6	0.6
Horizontal distance of the centre of the trunnions in rear of the vertical plane passing through the centre of the axletree	-	-	-	1.9	1.9	1.9
Distance from the axis of the trunnions to that of the axletree	-	-	-	28.21	27.5	26.3
Height of the axis of the piece above the platform, the piece being in battery	-	-	-	50.75	50.0	48.75
Length from the front of the wheels to the extremity of the lunette or trail, (length of the top casemate carriage, nearly)	-	-	-	69.0	69.0	69.0
Vertical field of fire, $\left\{ \begin{array}{l} \text{above the horizontal line,} \\ \text{below the horizontal line,} \end{array} \right\}$ nearly	-	-	-	7° 4°	8° 4°	9° 4°
Lateral field of fire, (centre of pintle of barbette carriage being 35 inches from the face of a vertical parapet)	-	-	-	53°	55°	58°
Inclination of the chassis, in 10 feet	-	-	-	7.75	7.75	7.75
Whole length of chassis, from front end of the rail to the rear of the tongue	-	-	-	188.15	188.15	188.15
Distance from centre of pintle to front end of rails, upper side	-	-	-	50.2	50.2	50.2
Horizontal distance from centre of pintle to centre of rear traversing wheels	-	-	-	194.5	194.5	194.5
Horizontal distance from centre of pintle to centre of front traversing wheels	-	-	-	62.5	62.5	62.5
Horizontal distance from centre of pintle to the face of the muzzle, the piece being in battery	-	-	-	0.0	0.0	0.0
				76.7	74.73	74.09

Width of the chassis	46.76	44.5	40.	53.55	51.3	45.
Distance between the exterior faces of the carriage wheels	46.76	44.5	40.	67.6	64.65	58.4
Whole length of the axletree	55.2	53.0	48.5	69.2	66.25	60.0
Distance from the centre of the axletree to the rear of the rear transom	-	-	-	61.2	60.0	60.0
Distance from the centre of the axletree to centre of pintle, (the piece in battery)	66.25	66.25	66.25	2.0	2.0	2.0
Wheels, { Diameter of front traverse wheel, (mean)	7.8	7.8	7.8	-	-	-
{ Diameter of rear traverse wheel, do.	15.9	15.9	15.9	15.0	15.0	15.0
{ Diameter of top carriage wheel	20.0	20.0	20.0	43.5	43.5	43.5
{ Diameter of flanged roller	-	-	-	13.9	13.9	13.9
{ Dish of finished wheel	-	-	-	1.25	1.25	1.25
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Top carriage, without wheels, { Oak	1090	975	908	-	1300	1132
{ Cypress	2150	1980	1846	-	1036	920
Chassis, without traverse wheels, { Oak	2329	3154	2100	-	-	-
{ Cypress	257	257	257	-	1717	1484
Weight of { Traverse wheels and forks	86	86	86	305	305	305
{ Pintle, (including pintle cross, bolster, plate, &c., of barbette carriage)	439	439	439	855	855	855
{ 2 carriage wheels, (including flanged rollers of barbette carriage)	4201	3954	3790	4377	3976	3380
{ Carriage and chassis complete, without implements, { Oak						
{ Cypress						

BILLS OF TIMBER FOR ARTILLERY CARRIAGES.

NAMES OF PARTS.		No. of pieces.	DIMENSIONS OF EACH PIECE.			REMARKS.
			Length.	Width.	Thickness.	
FIELD CARRIAGES.						
GUN CARRIAGE.—						
12-PDR. GUN	{ Stock -	2	110	11	5.5	} Oak.
and	{ Cheeks	2	52	16	4	
24-PDR. HOWITZER.	{ Axle body	1	50	7	6	
6-PDR. GUN	{ Stock -	2	102	9	4.5	
and	{ Cheeks	2	42	13.5	3	
12-PDR. HOWITZER.	{ Axle body	1	50	6.5	5.5	
HANDSPIKE	- - -	1	60	3.25	3.25	Hickory.
CAISSON.—						
Stock -	- - -	1	84	5.5	4.75	} Oak.
Axle body	- - -	1	50	5.5	5.5	
Middle rail	- - -	1	76	5.5	4.5	
Side rails	- - -	2	78	4.5	3	
Cross bar	- - -	1	40	4	2.5	
Front foot board	- - -	1	42	7.5	2	
Rear foot board	- - -	1	42	5	1	
FORGE.—						
Stock -	- - -	1	84	5.5	4.5	} Oak.
Axle body	- - -	1	50	5.5	5.5	
Side rails	- - -	2	90	4.5	3.5	
Cross bars	- - -	4	40	14	3.25	
Studs, plates and guides	- - -	2	42	10	3	} Walnut.
Cover for ends	- - -	1	40	15	2	
Cover for sides and top	- - -	12	132	7	0.75	White pine.
COAL BOX.	{ Ends -	2	26	15	1.12	} Walnut.
	{ Sides -	2	36	19	1.12	
	{ Lid -	1	36	14	1.12	
	{ Bottom -	1	36	15	1.12	
BELLOWS.—Plank	- - -	6	40	16	2	Oak.
BATTERY WAGON.—						
Stock -	- - -	1	108	6.5	6	} Oak.
Axle body	- - -	1	50	6	6	
Bottom rails	- - -	2	116	6.5	4	
Upper rails and cover rails	- - -	4	108	3	3	
Middle cross bars	- - -	4	42	13.5	4.5	
Front cross bar	- - -	1	42	5.5	5	
Bottom	- - -	3	108	12	1.25	} White pine.
Sides -	- - -	2	108	22	1.25	
Ends of body	- - -	2	42	24	1.25	} Walnut.
Cover -	- - -	9	108	7	0.625	
Ends of cover	- - -	2	42	16	1.25	} White pine.
End cross pieces	- - -	2	42	3	3	
Ridge pole	- - -	1	100	3	3	} Walnut.
End studs	- - -	2	18	3	2	
FORAGE RACK.	{ Sides	2	36	5.5	2	} Oak.
	{ Bars	3	46	3.5	1	
BOXES, for tools, &c.	- - -	2	96	10	1	} White pine.
	- - -	1	120	18	1	
LIMBER.—						
Axle body	- - -	1	50	5.5	6	} Oak.
Hounds	- - -	1	58	4.5	3.5	
Splinter bar	- - -	1	72	3.5	3.25	
Fork	- - -	1	42	9	4	

NAMES OF PARTS.	No. of pieces.	DIMENSIONS OF EACH PIECE.			REMARKS.
		Length.	Width.	Thickness.	
FIELD CARRIAGES.—Continued.		In.	In.	In.	
LIMBER.—Continued.					
Pole - - -	1	132	4.5	3.5	Ash.
Front foot board - -	1	46	8.5	1	} Oak.
Rear foot board - -	1	46	5	1	
Brackets - - -	1	15	3.5	2	
AMMUNITION CHEST.—					
Sides - - -	2	44	17	1.25	} Walnut.
Ends - - -	2	22	17	1.25	
Frame for cover - -	2	69	3.5	2	
Pannel for do. - -	1	44	18	2	Poplar.
Bottom - - -	1	42	20	1.25	Oak or walnut.
Cover lining - - -	1	40	20	0.5	Poplar.
Principal partition -	1	19	16	1.25	Walnut.
WHEEL.—					
Nave - - -	1	16	14		Walnut or oak.
Spokes - - -	14	32	3.5	2	} Oak.
Fellies - - -	7	27	7	3.5	
MOUNTAIN HOWITZER CARRIAGE.					
Stock - - -	2	66	9	7	} Oak.
Axle tree - - -	1	44	5.5	4.5	
WHEEL. { Nave - - -	1	11	9		} Oak or walnut.
Spokes - - -	12	20	2.5	1.5	
Fellies - - -	6	21	5.5	2.5	} Oak.
HANDSPIKE - - -	1	54	2.5	2.5	
SIEGE CARRIAGES.					
24-PDR. GUN CARRIAGE.—					
Stock - - -	2	126	11	8.5	} Oak.
Cheeks - - -	2	60	20.5	6	
Axle body - - -	1	50	9.5	8.5	
Breech bolster - -	1	15	7	7	
LIMBER.—					
Pole - - -	1	142	5.5	4.5	Ash.
Hounds - - -	1	50	5	4	} Oak.
Splinter bar and double tree	2	72	4	3.5	
Fork - - -	1	60	11	7.5	
WHEEL.—					
Nave - - -	1	19	16		} Oak.
Spokes - - -	14	32	4.5	2.5	
Fellies - - -	7	28	8.5	4.5	
Dowels - - -	28	10	1.25	1.25	

BILLS OF TIMBER.

NAMES OF PARTS.			No. of pieces.	DIMENSIONS OF EACH PIECE									REMARKS.	
				42-POUNDER.			32-POUNDER.			24-POUNDER.				
				Length.	Width.	Thickness.	Length.	Width.	Thickness.	Length.	Width.	Thickness.		
				In.	In.	In.	In.	In.	In.	In.	In.	In.		
GARRISON AND SEA COAST CARRIAGES.														
CASEMATE.														
TOP CARRIAGE.	Cheeks	-	2	69	17	6.5	69	16.5	6	69	15.5	5.5	Oak.	
	Front transom	-	1	26	16.5	6.75	24	16.5	6.25	22	16.5	5.5		
	Rear transom	-	1	32	18.5	6.75	30	18.5	6.25	27	18.5	5.5		
	Axletree	-	1	63	9	7	60	9	7	54	9	7		
	Roller	-	1	42	11.5	11.5	40	11.5	11.5	38	10	10		
CHASSIS.	Quoin	-	1	30	12	8.5	30	12	8.5	30	12	8.5	Hickory. Oak.	
	Tongue	-	1	216	14	13	216	13.5	12	216	12	11		
	Rails	-	2	162	14	12	162	13.5	11.5	162	12	11		
	Hurters and guides	-	1	114	7	6	114	7	6	114	7	6		
	Front transom	-	1	55	16.5	14.5	54	16.5	14.5	48	16.5	14.5		
BARBETTE.	Rear transom	-	1	73	16.5	14.5	72	16.5	14.5	66	16.5	14.5	Oak.	
	Prop	-	1	30	12	12	30	12	12	30	11	11		
	Uprights	-	2	54	18.5	6.5	56	18	6	54	17.5	5.25		
	Braces	-	2	84	15	6.5	84	14.5	6	84	13	5.5		
	Front transom	-	1	30	13.5	9	27	12	9	24	12	9		
TOP CARRIAGE.	Middle transom	-	1	30	12	9	27	10.75	9	24	9	9	Oak.	
	Rear transom	-	1	30	14	11	27	14	11	24	14	10		
	Transom & axle tie	-	1	84	11	11	84	11	10	84	11	9		
	Elevating bed	-	1	28	11	7	28	10	7	28	9	7		
	Axle body	-	1	42	8.5	8.5	39	8.5	8	36	8.5	8		
CHASSIS.	Spokes of wheel	-	10	22	4.25	4.25	22	4.25	4.25	22	4.25	4.25	Oak.	
	Tongue	-	1	198	13	11	198	12	10	198	11	9		
	Rails	-	2	148	15	10	148	14	9	148	13	8		
	Hurters	-	1	80	10	5	80	9	5	80	8	5		
	Front transom	-	1	60	11	9	54	9	9	51	9	9		
HANDSPIKE	Middle transom	-	1	60	10	10	54	10	9	51	9	8	Hickory.	
	Rear transom	-	1	60	11	9	54	9	8	51	9	8		
	Prop	-	1	40	11	4	40	10	4	40	10	4		
		-	1	66	4	4	66	4	4	66	4	4		
		-	1	66	4	4	66	4	4	66	4	4		
GINS.														
NAMES OF PARTS.			No. of pieces.	SIEGE AND GARRISON.			CASEMATE.			RAMPART.				
				Length.	Width.	Thickness.	Length.	Width.	Thickness.	Length.	Width.	Thickness.		
				In.	In.	In.	In.	In.	In.	In.	In.	In.		
Legs	-	-	2	180	6	5	180	12	9	264	12	9		
Pry pole	-	-	1	180	5	5	180	8	8	264	8	8		
Windlass	-	-	1	68	9	9	102	11	11	105	11	11		
Hanspike	-	-	1	80	3.5	3.5	60	4	4	60	4	4		
Upper cross bar	-	-	1	48	4.5	2.5								
Middle cross bar	-	-	1	72	4.5	2.5								
Lower cross bar	-	-	1	102	4.5	2.5								

BILLS OF IRON FOR ARTILLERY CARRIAGES.

NAMES OF PARTS.	Width.	Thickness.	Length.	TOTAL OF EACH SIZE.	
				Length.	Weight.
	In.	In.	In.	In.	lbs.
12-PDR. FIELD CARRIAGE.					
GUN CARRIAGE BODY.					
3 chains for cap-square keys and ear plate	wire.	No. 8	45	45	0.16
1 lock chain ring	0.25	round	5		
2 cap square chains	0.25	do.	20		
2 eye pins for chains and cap squares	0.25	do.	8		
2 eye pins for cap square key chains	0.25	do.	9		
1 eye pin for key chain of ear plate	0.25	do.	4.5	46.5	0.62
12 nails for trunnion plates	0.375	do.	24		
20 nails for guard plate, sponge stop and linstock socket	0.375	do.	30		
6 nails for axle bands	0.375	do.	6		
1 lock chain	0.375	do.	144	204	6.25
2 bolts for pointing ring plate	0.5	do.	14		
2 bolts for pointing ring	0.5	do.	17		
2 bolts for elevating screw box	0.5	do.	20		
2 sponge and worm hooks	0.5	do.	47		
2 D rings for handspikes	0.5	do.	36		
30 nails for lunette, prolonge hook, ear and eye plates, and sponge plate	0.5	do.	60	194	10.6
1 lock chain bolt	1.	do.	10		
3 assembling bolts	1.	do.	66		
6 round head bolts	1.	do.	92		
3 stock stirrup bolts	1.	do.	36	204	44.37
1 elevating screw	2.	do.	17	17	14.83
2 eye pins for cap square	0.5	0.25	2	2	0.07
2 keys for sponge hasps	1.	0.5	4		
1 key for ear plate	1.	0.5	2.5		
6 nuts for $\frac{1}{2}$ inch bolts	1.	0.5	6	12.5	1.75
2 trail handle bolts	1.	1.	14	14	4.
1 eye plate for sponge chain	1.25	0.375	3.5		
2 hasps for do.	1.25	0.375	8	11.5	1.5
2 trail handles	1.25	0.625	20		
2 nuts for trail handle bolts	1.25	0.625	2.5	22.5	4.9
2 axle shoulder washers	1.375	0.5	26		
2 linch washers	1.375	0.5	19	45	8.66
2 axle bands	1.5	0.25	39	39	4.1
1 large pointing ring	1.5	0.5	8		
2 washers for screw box bolts	1.5	0.5	3	11	2.31
1 lock chain hook	1.5	0.625	6	6	1.58
2 linch pins	1.5	0.75	16	16	5.
2 plates for sponge hasps	1.5	1.5	4	4	2.52
1 small pointing ring	1.75	0.5	11		
2 cap square keys	1.75	0.5	6	17	4.16
14 nuts for 1-inch bolts	1.75	1.	24.5	24.5	12.
1 plate and stud for pointing ring	2.	0.5	6	6	1.68
2 prolonge hooks	2.	0.75	12	12	5.04
2 chin bolts	2.	1.	20		
2 key bolts	2.	1.	18	38	21.28
1 eye plate for lock chain	2.25	0.625	3.5		
1 washer hook for do.	2.25	0.625	4.		
2 washer hooks for handspikes	2.25	0.625	12	19.5	7.67
1 ear plate for worm	2.5	0.5	3	3	1.05
Handles and head for elevating screw	2.5	1.75	6	6	7.35
10 washers for 1-inch bolts	3.	0.15	30	30	3.25
2 bevel washers for chin bolts	3.	0.625	3.5	3.5	1.84

BILLS OF IRON.

NAMES OF PARTS.	Width.	Thickness.	Length.	TOTAL OF EACH SIZE.	
				Length.	Weight.
	In.	In.	In.	In.	lbs.
12-PDR. CARRIAGE BODY—Continued.					
1 sponge and rammer stop - - - -	3.25	0.1875	4.75	4.75	0.81
2 cap squares - - - - -	3.25	0.625	46		
2 understraps - - - - -	3.25	0.625	54		
1 stock stirrup - - - - -	3.25	0.625	21	121	68.77
2 trunnion plates, - - - - -	3.25	1.	80	80	72.8
1 axletree, - - - - -	3.56	3.15	82	82	252.
1 linstock socket - - - - -	3.75	0.1875	6	6	1.18
2 wheel guard plates - - - - -	5.	0.1875	9	9	2.35
1 trail plate - - - - -	6.5	0.1875	18	18	6.12
1 trail lunette, - - - - -	6.5	1.5	15	15	20.5
6 assembling rondelles, (cast iron)	-	-	-	-	-
1 box for elevating screw, (brass)	-	-	-	-	-
Total -	-	-	-	-	603.07
LIMBER.					
1 chain for pintle hook key - - - -	0.25	round	24		
1 pole prop ring - - - - -	0.25	do.	10	34	0.5
1 rivet for rear end of pole - - - -	0.375	do.	2.5		
4 rivets for hounds - - - - -	0.375	do.	7		
1 staple for pintle key chain - - - -	0.375	do.	5		
2 nails for tar bucket hook - - - -	0.375	do.	3.5		
20 nails for foot boards - - - - -	0.375	do.	30		
2 pole chains - - - - -	0.375	do.	120	168	5.15
1 eye pin for pole prop - - - - -	0.625	do.	2		
2 branches for pole yoke - - - - -	0.625	do.	36	38	3.23
2 bolts for axle body - - - - -	0.75	do.	22		
3 bolts for pintle hook - - - - -	0.75	do.	28	50	6.12
2 keys for stays of ammunition chest	1.	do.	3	3	0.65
1 washer for pole muff - - - - -	0.5	0.25	11	11	0.40
2 burrs for eye pin and pole rivet -	0.75	0.125	1.5	1.5	0.04
2 rings for pole yoke - - - - -	1.	0.5	6		
1 key for pole muff - - - - -	1.	0.5	2		
1 nut for pole bolt - - - - -	1.	0.5	1		
4 trace hooks - - - - -	1.	0.5	20	29	4.06
2 bolts for splinter bar and hounds	1.	1.	9		
2 bolts for splinter bar and fork -	1.	1.	8		
4 bolts for understraps - - - - -	1.	1.	14		
2 bolts for collar of pole yoke - - -	1.	1.	4		
1 pole bolt - - - - -	1.	1.	5.5	40.5	11.34
1 tar bucket hook - - - - -	1.25	0.25	5		
1 ferrule for pole prop - - - - -	1.25	0.25	5.5	10.5	0.92
6 nuts for axle body and understrap bolts	1.25	0.625	9		
7 nuts for splinter bar and pintle bolts	1.25	0.625	8.75	17.75	3.86
2 axle shoulder washers - - - - -	1.375	0.5	26		
2 lynch washers - - - - -	1.375	0.5	19	45	3.66
6 washers for pole bolt and splinter bar bolts	1.5	0.1	9	9	0.37
4 plates for stay pins of ammunition chest	1.5	0.125	12	12	0.63
1 collar for pole yoke - - - - -	1.5	0.625	10		
2 stay pins for ammunition chest - -	1.5	0.625	6	16	4.20
2 lynch pins - - - - -	1.5	0.75	16	16	5.
1 pintle key - - - - -	1.5	1.5	8	8	5.
1 fork strap - - - - -	1.75	0.25	12	12	1.47
1 eye plate for pole prop socket - -	1.75	0.5	7	7	1.72

NAMES OF PARTS	Width.	Thick- ness.	Length.	Weight.
In.	In.	In.	lbs.	
12-PDR. FIELD CARRIAGE—LIMBER—Continued.				
4 washers for axle body and pintle bolts	2.	0.125	8	0.56
2 end bands for splinter bar	2.	0.5	12	} 6.16
2 middle bands for do.	2.	0.5	10	
1 pole strap-ring	2.25	0.5	12	3.78
1 stay for ammunition chest	2.75	0.5	6	2.31
2 understraps	3.	0.5	44	18.5
1 pole prop socket	3.	0.625	7	3.67
1 axletree,	3.	2.125	82	146.37
1 pintle hook,	4.	4.	10	44.8
1 pole muff	4.25	0.25	9	2.67
Total	-	-	-	287.14
AMMUNITION CHEST.				
1 assembling bolt	0.375	round.	22	0.68
2 handles	0.75	do.	42	5.15
1 nut for assembling bolt	1.	0.5	1	0.14
1 turnbuckle	1.	1.	1.75	0.5
3 straps	1.25	1.25	20	8.75
2 hinges	1.5	0.75	60	18.9
1 plate for assembling bolt	1.75	0.125	2.25	0.15
1 hasp and strap	2.25	0.5	5	1.58
5 corner plates	15.	0.125	27.5	14.44
Sheet copper,	Wire gauge 8-oz. nails		48	
300 copper nails,				
Total	-	-	-	50.29
WHEEL.				
12 nails for nave bands	0.375	round.	10	0.31
7 tire bolts	0.5	do.	42	2.3
7 nuts for do.	1.	0.5	7	1.
2 end bands for nave	1.25	0.2	57	} 8.61
2 brow bands for do.	1.25	0.2	66	
7 washers for tire bolts	1.5	0.1	10.5	0.44
1 tire	2.75	0.625	178	85.6
1 nave box, (cast iron)	-	-	-	-
Total	-	-	-	98.26
LIGHT 6-PDR. FIELD CARRIAGE.				
GUN CARRIAGE BODY.				
Chains for cap square and ear plate keys	wire.	No. 8	45	0.16
Lock chain ring, cap square chains, and eye pins	0.25	round.	46.5	0.62
Lock chain	0.375	do.	144	4.42
2 sponge and worm hooks, 6 bolts for pointing rings and elevating screw box, 2 D rings	0.5	do.	131	7.14
6 round head bolts, 2 assembling bolts, and 3 axle strap bolts	0.75	do.	152	18.61
1 assembling bolt	1.	do.	20	4.35
1 elevating screw	2.	do.	15	13.08
2 eye pins for cap squares	0.5	0.25	2	0.07
8 nuts for small bolts, keys for ear plate and sponge chain	1.	0.5	14.5	2.
Lock chain bolt, 2 trail handle bolts	1.	1.	19	5.32
Eye plate and hasps for sponge	1.25	0.375	11.5	1.5

BILLS OF IRON.

NAMES OF PARTS.					Width.	Thick- ness.	Length.	Weight.
					In.	In.	In.	lbs.
LIGHT 6-PDR. CARRIAGE—Continued.								
2 trail handles	-	-	-	-	1.25	0.625	20.	4.37
14 nuts for large bolts	-	-	-	-	1.25	0.75	17.5	4.6
4 axle washers	-	-	-	-	1.375	0.5	45	8.66
2 washers for bolts of elevating screw box	-	-	-	-	1.5	0.1	3	0.13
2 axle bands	-	-	-	-	1.5	0.25	38	4.
2 cap square keys, 1 large pointing ring	-	-	-	-	1.5	0.5	13	2.73
Lock chain hook	-	-	-	-	1.5	0.625	6	1.58
2 linch pins	-	-	-	-	1.5	0.75	16	5.
2 plates for sponge hasps	-	-	-	-	1.5	1.5	4	2.52
1 pointing ring	-	-	-	-	1.75	0.5	11	2.7
2 chin bolts and 2 key bolts	-	-	-	-	1.75	0.75	38	14.
8 washers for large bolts	-	-	-	-	2.	0.125	16	1.12
2 bevel washers, 1 pointing ring plate	-	-	-	-	2.	0.5	9.5	2.66
2 prolonge hooks	-	-	-	-	2.	0.75	12	5.04
1 eye plate for lock chain, 3 washer hooks	-	-	-	-	2.25	0.625	19.5	7.67
2 understraps, 1 axle strap	-	-	-	-	2.375	0.5	72	23.82
2 trunnion plates,	-	-	-	Drafts, or	2.375	0.625	68	23.85
1 ear plate for worm	-	-	-	-	2.5	0.5	3	1.05
2 cap squares	-	-	-	-	2.5	0.75	28	14.7
Handles and head for elevating screw	-	-	-	-	2.5	1.75	6	7.35
1 axletree,	-	-	-	Draft, or	3.	3.	58	146.16
1 sponge and rammer stop	-	-	-	-	3.25	0.1875	4.75	0.81
1 linstock socket	-	-	-	-	3.75	0.1875	6	1.18
2 wheel guard plates	-	-	-	-	5.	0.1875	9	2.35
1 trail plate	-	-	-	-	5.25	0.1875	17	4.67
1 lunette,	-	-	-	Draft, or	5.25	1.5	15	33.
6 rondelles, (cast iron)	-	-	-	-				
1 box for elevating screw, (brass)	-	-	-	-				
Total								383.01
WHEEL.								
12 nails for nave bands	-	-	-	-	0.375	round.	10	0.31
7 tire bolts	-	-	-	-	0.5	do.	36	1.96
7 nuts for do.	-	-	-	-	1.	0.5	7	1.
7 washers for do.	-	-	-	-	1.25	0.1	10.5	0.37
4 nave bands	-	-	-	-	1.25	0.2	112	7.84
1 tire	-	-	-	-	2.75	0.5	178	68.52
1 nave box, (cast iron)	-	-	-	-				
Total								80.
MOUNTAIN HOWITZER CARRIAGE.								
28 nails, 12 tire bolts, 1 handspike staple	-	-	-	-	0.375	round.	75.5	2.31
Elevating screw	-	-	-	-	1.75	do.	11	7.34
12 nuts for tire bolts	-	-	-	-	0.75	0.375	9	0.7
4 nave bands and 2 axle bands	-	-	-	-	1.	0.2	108	6.
2 linch pins	-	-	-	-	1.	0.5	7	1.
5 assembling bolts, &c.	-	-	-	-	1.	1.	54	15.12
2 cap square keys	-	-	-	-	1.2	0.375	3	0.38
12 washers for tire bolts	-	-	-	-	1.25	0.1	15	0.52
2 travelling hooks	-	-	-	-	1.25	0.2	48	3.36
4 key and chin bolts, 9 nuts for bolts	-	-	-	-	1.25	0.75	41	10.76
4 washers for bolts	-	-	-	-	1.5	1.	6	2.52
2 axletree bands	-	-	-	-	2.	0.25	19	2.66
2 wheel tires	-	-	-	-	2.	0.375	234	49.14

NAMES OF PARTS.	Width.	Thickness.	Length.	TOTAL OF EACH SIZE.	
				Length.	Weight.
	In.	In.	In.	In.	lbs.
MOUNTAIN HOWITZER CARRIAGE—Continued.					
2 understraps	2.	0.5	32	32	9.
Head and handles for elevating screw	2.	1.75	4	4	3.92
2 trunnion plates and 2 cap squares	2.25	0.5	63	63	19.84
2 axle skeins	2.5	0.375	34	34	8.92
2 axle hook washers	2.5	0.5	6	6	2.1
1 lunette plate	3.75	0.5	12	12	6.3
2 chains for cap square keys		No. 10			
4 nave boxes, (cast iron)					
Jack chain					
Total					151.89
BATTERY WAGON.					
10 nails for wheel guard plates	0.25	round.	24		
2 forage rack chains	0.25	do.	324	348	4.73
2 rivets for ends of rails	0.375	do.	6		
2 rivets for cover rails	0.375	do.	4		
1 rivet for stock	0.375	do.	4		
8 rivets for angles of cover	0.375	do.	15		
6 rivets for cover bows	0.375	do.	10		
2 staples for hasp and cover strap	0.375	do.	6		
1 lock chain	0.375	do.	204	249	7.64
14 rivets for studs	0.4	do.	24	24	0.84
2 assembling bolts	0.75	do.	88	88	10.78
2 burrs for rail rivets	0.75	0.125	1.5	1.5	0.04
8 nuts for stud bolts	0.75	0.375	6		
4 nuts for cover bolts	0.75	0.375	6		
6 nuts for hinge bolts of cover	0.75	0.375	12	24	1.88
1 turnbuckle bolt	1.	1.	2		
11 bolts for end grooves	1.	1.	18		
8 bolts for studs	1.	1.	12		
1 hook for cover strap	1.	1.	4		
1 eye staple for hasp	1.	1.	3		
2 end stay bands	1.	1.	48		
1 bolt for foot of front stud	1.	1.	4.5		
3 bolts for feet of middle studs	1.	1.	12		
4 understrap bolts	1.	1.	22		
2 lunette bolts	1.	1.	9		
2 stock stirrup bolts	1.	1.	10		
2 bolts for cross bars and stock	1.	1.	16		
2 bolts for ends of left bottom rail	1.	1.	8		
1 bolt for end of right bottom rail	1.	1.	4		
1 lock chain bridle	1.	1.	5		
2 end bows for cover	1.	1.	42		
4 bolts for ends of cover	1.	1.	6		
6 hinge bolts for cover	1.	1.	12		
6 hinge rivets for do.	1.	1.	12		
1 hasp for do.	1.	1.	3.5	253	70.84
2 bands for sides of forage rack	1.25	0.1875	48	48	3.12
1 spare stock stirrup	1.25	0.375	21		
11 nuts for groove bolts	1.25	0.375	9	30	3.92
2 bolts for forage rack	1.25	1.25	7	7	3.06
4 axle washers	1.375	0.5	45	45	8.66
1 washer for stem of rear stud	1.5	0.1	1.5	1.5	0.06
4 squares for angles of cover	1.5	0.25	36		
2 middle bows for cover	1.5	0.25	108	144	15.12

BILLS OF IRON.

NAMES OF PARTS.	Width.	Thickness.	Length.	TOTAL OF EACH SIZE.	
				Length.	Weight.
BATTERY WAGON—Continued.					
	In.	In.	In.	In.	lbs.
1 lock chain hook - - - - -	1.5	0.625	6	6	1.58
21 nuts for 1-inch bolts - - - - -	1.5	0.75	31.5		
2 lynch pins - - - - -	1.5	0.75	16	47.5	15.
1 spare stock hook - - - - -	1.5	1.5	7		
1 turnbuckle for do. - - - - -	1.5	1.5	3	10	6.3
8 studs for sides of body - - - - -	1.625	0.5	180		
2 studs for ends of do. - - - - -	1.625	0.5	42	222	59.64
1 washer for bolt of right bottom rail - - - - -	1.875	0.125	1.875	1.875	0.12
10 washers for 1-inch bolts - - - - -	2.	0.125	20	20	1.4
2 oval washers for forage rack - - - - -	2.	0.1875	4	4	0.42
1 cover strap - - - - -	2.	0.5	20	20	5.6
2 understraps - - - - -	2.25	0.5	48		
1 stock stirrup - - - - -	2.25	0.5	24	72	22.68
1 axletree, - - - - -	3.	3.	58	58	146.16
4 end grooves - - - - -	3.4	0.2	88	88	16.76
3 hinges for cover - - - - -	4.	0.625	21	21	14.7
1 lunette - - - - -	4.	1.	48	48	53.76
2 wheel guard plates - - - - -	4.75	0.1875	10	10	2.5
1 mortice plate for axle body - - - - -	5.25	0.125	7.75	7.75	1.42
Total - - - - -					478.73
24-PDR. SIEGE CARRIAGE.					
GUN CARRIAGE BODY.					
2 key chains - - - - -	0.25	round.	40	40	0.54
2 cap square chains - - - - -	0.375	do.	72		
8 nails for axle bands - - - - -	0.375	do.	19	91	2.79
43 nails for lunette, trail and guard plates - - - - -	0.5	do.	98	98	5.34
Lock chain - - - - -	0.625	do.	120	120	10.2
1 lock chain ring - - - - -	0.75	do.	15		
2 bolts for elevating screw box - - - - -	0.75	do.	28		
2 breech bolster bolts - - - - -	0.75	do.	35		
2 lunette bolts - - - - -	0.75	do.	28	106	13.
2 bolts for head of stock - - - - -	1.	do.	32	32	6.96
Elevating screw - - - - -	2.5	do.	21	21	28.63
4 eye pins for cap square chains - - - - -	1.	0.375	5	5	0.53
1 nut for lock chain hook - - - - -	1.	0.625	1	1	0.18
1 lock chain hook - - - - -	1.	1.	9	9	2.52
4 axle washers - - - - -	1.25	0.5	18		
1 lunette rondelle - - - - -	1.25	0.5	12	30	
10 nuts for understrap bolts and ¾-inch bolts - - - - -	1.25	0.625	12.5	12.5	5.25
1 assembling bolt for stock - - - - -	1.25	1.25	17		
2 assembling bolts for cheeks - - - - -	1.25	1.25	63		
1 manœuvring bolt - - - - -	1.25	1.25	23		
4 cheek bolts - - - - -	1.25	1.25	88	191	84.
2 axle bands - - - - -	1.5	0.625	60	60	15.75
2 nuts for axle strap bolts - - - - -	1.75	1.	3.5	3.5	1.72
1 hook for lock chain - - - - -	2.	0.75	7		
2 lynch pins - - - - -	2.	0.75	16	23	9.66
8 washers for ¾-inch bolts and lock chain hook - - - - -	2.15	0.125	18	18	1.35
18 nuts for large bolts - - - - -	2.25	1.25	40.5	40.5	31.9
2 key bolts - - - - -	2.25	1.375	26	26	22.51
1 assembling ring bolt - - - - -	2.25	2.25	15	15	21.26

NAMES OF PARTS.	Width.	Thickness.	Length.	TOTAL OF EACH SIZE.		
				Length.	Weight.	
SIEGE CARRIAGE—Continued.					In.	lbs.
2 keys for cap squares - - - - -	2.5	0.625	7	7	3.06	
2 bevel washers - - - - -	2.5	1.25	8	8	7.	
2 chin bolts - - - - -	2.5	1.375	24	24	23.1	
2 travelling trunnion bolts - - - - -	2.75	1.5	24	24	27.72	
1 axle strap - - - - -	3.	0.625	13	13	6.82	
Head and handles for elevating screw	3.5	2.	9	9	17.64	
Axletree, - - - - - Draft, or	3.5	3.5	76	76	260.68	
16 washers for large bolts - - - - -	4.	0.25	68	68	19.04	
2 collars for manœuvring bolts - - - - -	4.25	0.3	16	16	5.71	
2 understraps - - - - -	4.5	0.875	76	76	83.73	
2 cap squares - - - - -	4.75	0.875	42	42	48.86	
2 trunnion plates - - - - -	4.75	1.2	114	114	181.74	
2 wheel guard plates - - - - -	6.25	0.25	13	13	5.69	
1 lunette plate - - - - -	7.	0.75	12	12	17.64	
1 trail plate - - - - -	9.	0.5	41	41	51.66	
6 assembling rondelles, (cast iron)						
1 box for elevating screw, (brass)						
Total - - - - -					1024.18	
LIMBER.						
4 nails for fork bridle - - - - -	0.375	round.	8			
1 pole rivet - - - - -	0.375	do.	4			
2 rivets for ends of hounds - - - - -	0.375	do.	7	19	0.58	
2 pole chains - - - - -	0.4	do.	120	120	4.19	
7 nails for saddle plate - - - - -	0.5	do.	15			
1 pole band key - - - - -	0.5	do.	3	18	0.82	
1 lashing chain - - - - -	0.625	do.	36			
3 eye staple bolts - - - - -	0.625	do.	16	52	4.42	
1 saddle bolt - - - - -	0.75	do.	12			
2 ear bolts - - - - -	0.75	do.	9			
4 understrap bolts - - - - -	0.75	do.	28			
6 axle strap bolts - - - - -	0.75	do.	54			
4 splinter bar bolts - - - - -	0.75	do.	34			
2 pole bolts - - - - -	0.75	do.	28	165	20.21	
1 double hook for double tree - - - - -	1.	do.	10	10	2.18	
3 nuts for eye staple bolts - - - - -	1.	0.625	3	3	0.52	
4 axle washers - - - - -	1.25	0.5	18	18	3.15	
11 nuts for $\frac{3}{4}$ -inch bolts - - - - -	1.25	0.625	13.75			
4 trace hooks and 2 splinter bar hooks	1.25	0.625	48	61.75	13.48	
1 pole ferrule - - - - -	1.75	0.3	10	10	1.43	
1 fork bridle - - - - -	1.75	0.375	15	15	2.75	
1 hook for lashing chain - - - - -	2.	0.75	5	5	2.1	
1 hook for double tree - - - - -	2.	1.	6	6	3.36	
11 washers for $\frac{3}{4}$ -inch bolts - - - - -	2.15	0.125	24.75	24.75	1.83	
1 bridle for end of fork - - - - -	2.25	0.5	16	16	5.04	
1 nut for pintle - - - - -	2.25	1.25	2.25	2.25	1.77	
1 pole band - - - - -	2.5	0.5	9			
1 middle band for double tree - - - - -	2.5	0.5	12	21	9.45	
2 middle bands for splinter bar - - - - -	2.5	0.625	17			
4 end bands for splinter bar and double tree	2.5	0.625	30	47	20.56	
1 pintle - - - - -	2.5	2.5	13	13	22.75	
2 understraps - - - - -	3.	0.625	44	44	23.1	
1 axletree, - - - - - Draft, or	3.5	3.5	76	76	260.68	
1 washer for pintle - - - - -	4.	0.25	4.25	4.25	1.2	
1 sweep bar - - - - -	4.1	0.9	46	46	47.15	

BILLS OF IRON.

NAMES OF PARTS.						Width.	Thickness.	Length.	TOTAL OF EACH SIZE.	
									Length.	Weight.
SIEGE CARRIAGE—LIMBER—Continued.										
1 double axle strap	-	-	-	-	-	5.5	0.625	31	31	29.84
1 eye staple for end of pole	-	-	-	-	-	5.5	1.	10	10	15.4
1 saddle plate	-	-	-	-	-	8.	1.	15	15	33.6
Total										531.56
WHEEL.										
12 nails for nave bands	-	-	-	-	-	0.375	round.	24	24	0.74
7 tire bolts	-	-	-	-	-	0.75	do.	36	36	4.41
7 nuts for do.	-	-	-	-	-	1.25	0.625	8.75	8.75	1.91
2 brow bands for nave	-	-	-	-	-	1.5	0.375	92		
2 end bands for do.	-	-	-	-	-	1.5	0.375	78	170	26.77
7 washers for tire bolts	-	-	-	-	-	2.15	0.125	15.5	15.5	1.16
1 tire	-	-	-	-	-	4.	0.875	183.	183	179.34
1 nave box, (brass)	-	-	-	-	-					
Total										214.33
NAMES OF PARTS.						Width.	Thick-ness.	Length.	Weight.	
CASEMATE GIN.						Inches.	Inches.	Inches.	lbs.	
Nails and keys	-	-	-	-	-	0.5	round.	24	1.31	
Bolts	-	-	-	-	-	1.	do.	72	15.36	
Bolt for clevis	-	-	-	-	-	1.75	do.	24	16.	
Washers	-	-	-	-	-	1.5	0.125	72	3.78	
Cross bars	-	-	-	-	-	1.5	1.25	216	113.4	
Clevis	-	-	-	-	-	1.5	1.5	18	11.34	
Middle bands and bands for windlass	-	-	-	-	-	2.	0.25	264	37.	
Gudgeons for windlass and points for legs	-	-	-	-	-	2.	2.	36	40.32	
Bands for windlass	-	-	-	-	-	3.5	0.25	60	14.70	
Lower bands	-	-	-	-	-	4.	0.25	84	23.52	
Top bands	-	-	-	-	-	6.	0.25	84	35.28	
2 ratchet wheels, (cast iron)	-	-	-	-	-	-	-	-		
2 boxes for gudgeons, (brass)	-	-	-	-	-	-	-	-		
Total									312.61	
SET OF GIN BLOCKS. *										
Bolts	-	-	-	-	-	1.	1.			
Swivels	-	-	-	-	-	1.5	1.5			
Hooks	-	-	-	-	-	1.75	1.75			
Cross plates	-	-	-	-	-	4.1	0.4			
Do. do.	-	-	-	-	-	4.1	0.75			
Side plates	-	-	-	-	-	6.5	0.625			
Centre plates	-	-	-	-	-	8.	0.25			

* The size of the sheave for these blocks is 7 inches. If the sheaves are increased in size, the dimensions of the iron must be increased in proportion.

NAMES OF PARTS.			Width.	Thickness.	42-POUNDER.		32-POUNDER.		24-POUNDER.	
					Length.	Weight.	Length.	Weight.	Length.	Weight.
CASEMATE CARRIAGE.			In.	In.	In.	lbs.	In.	lbs.	In.	lbs.
TOP CARRIAGE.	Bolts	-	1.	round.	524	114.	539	117.25	508	111.5
	Roller skeins	-	0.625	0.375	34	2.3	34	2.3	34	2.3
	Side axle skeins	-	0.875	0.375	27	2.5	27	2.5	27	2.5
	Linch pins	-	1.125	0.75	11	2.6	11	2.6	11	2.6
	Cheek plates	-	1.375	0.1875	66	4.75	66	4.75	61	4.5
	Axle and roller bands	-	1.375	0.25	105	10.25	105	10.25	99	9.75
	Friction-roller boxes	-	1.375	0.75	12	3.5	12	3.5	12	3.5
	Top and bottom axle skeins	-	1.625	0.375	25	4.25	25	4.25	25	4.25
	Trail handles	-	1.75	0.75	28	10.5	28	10.5	28	10.5
	Heads and nuts for inch bolts	-	2.	1.	98	54.	103	57.	103	57.
	Washers for small bolts	-	2.5	1.125	-	-	11	1.	11	1.
	Axle shoulder plates	-	3.25	0.25	13	3.	13	3.	13	3.
	Washers for inch bolts	-	3.375	0.1875	42	7.5	49	8.7	49	8.7
	Roller plates and straps,	{	4.875	0.5	-	-	-	-	208	142.
	axle straps, and		5.625	0.5	-	-	209	164.	-	-
	trunnion plates		6.125	0.5	218	187.	-	-	-	-
	FOR ELEVATING { Bolts	-	0.625	round.	-	-	29	2.5	26	2.25
	MACHINE { Sockets	-	2.	1.	-	-	19	10.7	19	10.7
	2 TRUCK HANDSPIKES	-	1.5	1.5	72	45.5	72	45.5	72	45.5
	BUCKET {	Handle	0.5	round.	16	0.9	16	0.9	16	0.9
		Ears	1.25	0.25	9	0.8	9	0.8	9	0.8
	Total	-				453.35		452.		423.3
CHASSIS.	Rail plate nails	-	0.375	round.	185	5.75	185	5.75	185	5.75
	Bolts	-	1.	round.	251	54.5	249	54.	213	46.3
	Caps for journal boxes	-	2.	0.25	68	9.5	68	9.5	68	9.5
	Heads and nuts for inch bolts	-	2.	1.	82	46.	82	46.	73	41.
	Double washers	-	2.25	0.25	33	5.25	33	5.25	20	3.15
	Tongue plates	-	2.5	0.5	42.5	15.	42.5	15.	42.5	15.
	Transom strap and tongue brace	-	3.	0.5	105	44.25	102.5	43.	98	41.25
	Washers for inch bolts	-	3.375	0.1875	29	5.25	29	5.25	29	5.25
	Rail plates, (in 2 pieces)	-	5.125	0.375	272	146.	272	146.	272	146.
	Tongue and fork, 2 Drafts	-				119.		119.		119.
	Total	-				450.5		448.75		432.2

BILLS OF IRON.

NAMES OF PARTS.		Width.	Thick- ness.	32-POUNDER.		24-POUNDER.	
				Length.	Weight.	Length.	Weight.
BARBETTE CARRIAGE.		In.	In.	In.	lbs.	In.	lbs.
TOP CARRIAGE.	Trail rivet bolts - -	0.5	round.	30.	1.75	26.	1.5
	Manœuvring staples - -	0.75	round.	34.	4.25	34.	4.25
	Assembling and tie bolts - -	1.	round.	308.	67.	250.	54.4
	Cheek bolts - - -	1.25	round.	68.	23.	63.	21.5
	Elevating screw - - -	2.5	round.	25.	34.	25.	34.
	Manœuvring bolts - - -	1.25	1.25	65.	28.5	65.	28.5
	Linch pins - - -	1.5	1.	7.7	3.25	7.7	3.25
	Axle washers - - -	1.75	0.4375	61.	13.	54.	11.5
	Stirrups, bridles and nuts - -	2.	0.75	72.	30.25	72.	30.25
	Heads and nuts for inch bolts -	2.	1.	54.	30.25	48.	27.
	Heads and nuts for large bolts -	2.625	1.25	16.	14.5	16.	14.5
	Double washer - - -	3.	0.1875	8.5	1.35	8.5	1.35
	Clamp washer - - -	3.	0.5	15.	6.25	15.	6.25
	Handles for elevating screw -	3.25	1.75	14.	22.25	14.	22.25
	Washers for inch bolts - -	3.375	0.1875	50.	8.75	42.	7.5
	Washers for large bolts - -	4.	0.1875	36.	7.5	36.	7.5
	Lunette - - -	4.	1.5	16.	28.	16.	28.
	Collars for manœuvring bolts -	4.125	0.375	14.	6.	14.	6.
	Axletree, - - - Draft				231.		159.
	WHEELS { Tire nails - -	0.5	round.	52.	3.	52.	3.
	{ Tires, (in 2 pieces) -	4.5	0.875	280.	308.	280.	308.
BUCKET	{ Handle - - -	0.5	round.	16.	0.9	16.	0.9
	{ Ears - - -	1.25	0.25	9.	0.8	9.	0.8
	Total - - -				873.55		781.2
CHASSIS.	Rivets, nails, loop and prop bolts - - -	0.5	round.	192.	10.45	191.	10.4
	Assembling bolts - - -	1.	round.	267.	58.	252.	55.
	Fork bolts - - -	2.	round.	15.	13.	15.	13.
	Heads and burrs for rivets - -	1.25	0.5	17.5	3.	17.5	3.
	Prop plates - - -	1.625	0.375	21.	3.5	21.	3.5
	Manœuvring loop - - -	2.	0.375	15.	3.	15.	3.
	Bolt heads and nuts - - -	2.	1.	81.	45.5	78.	44.
	Tongue brace, (1st piece) - -	3.	0.5	34.7	14.5	-	-
	Washers - - -	3.375	0.1875	28.	5.	28.	5.
	Transom strap - - -	3.5	0.5	35.7	17.5	44.	21.5
	Fork sockets - - -	6.5	0.25	19.	8.5	19.	8.5
	Tongue brace, (2d piece) - -	7.5	0.5	15.	15.75	-	-
	Fork plates - - -	10.	0.875	16.6	40.5	16.6	40.5
	Forks, - - - 2 Drafts				92.		92.
	Total - - -				330.2		299.4
PINTLE CROSS.	Bolster plate bolts - -	0.75	round.	78.	9.5	78.	9.5
	Nuts for do. - - -	1.5	0.75	7.3	2.5	7.3	2.5
	Washers for do. - - -	2.5	0.125	11.	1.	11.	1.
	Pintle washer - - -	4.	0.1875	4.5	1.	4.5	1.
	Pintle - - - Draft	-	-	-	16.	-	16.
	Total - - -				30.		30.

CHAPTER FOURTH.

ARTILLERY IMPLEMENTS AND EQUIPMENTS.

NOMENCLATURE, DIMENSIONS, WEIGHTS.

RAMMER HEADS: *Body, ogee, neck, staff socket.*

Diameter of body *seven-eighths* of a calibre; length of rammer-head $1\frac{1}{2}$ calibre for field guns, 1 calibre for others.

KIND.	Length.	DIAMETER.	
		Body.	Neck
	In.	In.	In.
42-pounder gun and 10-inch sea coast howitzer -	7	6.13	3
32-pounder gun and 8-inch sea coast howitzer -	6.4	5.6	3
24-pounder gun - - - - -	5.8	5.1	3
18-pounder gun - - - - -	5.3	4.64	3
12-pounder gun, 8-inch siege howitzer, 24-pounder howitzer, 13-inch and 10-inch mortars (heavy)	7.	4.	2.5
9-pounder gun - - - - -	6.25	3.68	2.5
6 pounder gun, 12-pounder howitzer, 10-inch mortar (light,) 8-inch mortar and stone mortar -	5.5	3.24	2.5

Rammer heads are made of ash, maple, birch, beech, elm, gum, or other tough woods; the head is bored $\frac{2}{3}$ of its length with a hole 0.25 inch less than the diameter of the staff which enters with a tenon. The staff is driven into the head and fastened with a *pin* of hard wood 0.3 inch diameter: the neck has a *copper band* 0.5 inch wide and 0.05 inch thick, fastened with 3 *copper nails*.

Rammer heads for howitzers are countersunk in the form of a spherical segment, to receive the fuzes in ramming shells.

SPONGE HEADS: *Body, rounded ends, staff socket.*

Diameter, 1 inch less than the calibre of the piece; this is the size required for the wove woollen sponge.

Length, for sea coast and siege cannon 8 inches, except the 12-pounder which is 7.5 inches; for field cannon 7.5 inches.

KIND.	Length.	Diameter.
	Inches.	Inches.
42-pounder gun and 10-inch sea coast howitzer -	8.	6.0
32-pounder gun and 8-inch sea coast howitzer -	8.	5.4
24-pounder gun - - - - -	8.	4.8
18-pounder gun - - - - -	8.	4.3
12-pounder gun, 8-inch siege howitzer 24-pounder howitzer, 13-inch and 10-inch mortars (heavy) -	7.5	3.6
9-pounder gun - - - - -	7.5	3.2
6-pounder gun, 12-pounder howitzer, 10-inch mortar (light,) 8-inch mortar and stone mortar -	7.5	2.7

Sponge heads are made of elm or poplar, &c. The head is bored $\frac{2}{3}$ of its length, with a hole 0.25 inch less than the body of the staff which is inserted with a tenon and fastened by 2 hard wood *pins* 0.3 inch diameter.

SPONGES are made of coarse, well twisted woollen yarn, woven into a warp of strong hemp or flax thread, after the manner of Brussels carpet; the loops are 0.75 inch long.

They are woven in webs with selvages between them, which being cut, the sponges are sewed to fit formers of the same dimensions as the sponge heads. One end of the sponge is drawn together with strong twine and a tuft of woollen yarn is inserted at the centre of the gather or folds; a circular piece of strong canvass is stitched inside of the bottom; the other end, after receiving the sponge head, is nailed to it around the staff with 6 *copper nails*, 1 inch long; 3 *copper nails* should also be driven into the bottom of the sponge, to secure it to the head.

Similar sponges are made by working the yarn with needles into canvass bags, but the wove sponges are equally good and less expensive.

Sponges are likewise made of sheep skin alum-dressed, with the wool on; but they are inferior to those made of yarn.

For dimensions of sponges, see Table of sponge heads.

SPONGE COVERS.—*Body, circular end.*

They are made of Russia duck or canvass, painted the same color as the gun carriage.

The interior diameter is equal to the calibre of the piece; the length for field cannon is 9 inches, and for sea coast, garrison and siege, 11 inches. A *hem* 0.5 inch wide around the top receives a *cord* 0.2 inch diameter, by which the

mouth is drawn together and tied around the sponge staff: a *loop* of canvass 0.75 inch wide is sewed on the end of the cover to draw it off by.

The covers are marked in white with the calibre of the gun.

LADLE HEADS: *Body, shoulder, ogee, neck, staff-socket, band* (copper.)

Diameter of the body 0.4 inch less than the calibre of the piece; diameter of the shoulder, 0.3 inch less than a calibre; length, 1 calibre.

KIND.	Length.	DIAMETERS.		
		Shoulder.	Body.	Neck.
	Inches.	Inches.	Inches.	Inches.
42-pounder - - -	7.	6.7	6.6	3.
32-pounder - - -	6.4	6.1	6.	3.
24-pounder - - -	5.8	5.5	5.4	3.
18-pounder - - -	5.3	5.	4.9	3.
12-pounder - - -	4.6	4.3	4.2	2.5

Ladle heads are made of the same kinds of wood, and are fastened to the staff in the same manner, as rammer heads.

Rammer, ladle and sponge heads should be saturated, when new, with linseed oil, to prevent splitting from alternate wetting and drying in service.

LADLES, (copper,)—*Scoop, band, nails.*

Ladles are used for siege, garrison and sea coast guns only.

KIND.	Length. of ladle.	Length of the band (develop- ed.)	Width of the scoop.	Width of the band (included in first co- lumn.)
	Inches.	Inches.	Inches.	Inches.
42-pounder - - -	16.5	20.75	14.	2.5
32-pounder - - -	15.35	18.85	12.8	2.5
24-pounder - - -	14.1	16.95	11.6	2.5
18-pounder - - -	13.1	15.4	10.6	2.5
12-pounder - - -	11.2	13.2	9.2	2.0

The length of copper for ladles is 2 calibres, exclusive of the band which is 2.5 inches wide; thickness, 0.05 inch; the width of the copper (developed) at

the band, (2d column of the above table,) is equal to the circumference of the body of the ladle head; below the band, the width is equal to 2 calibres. Towards the mouth of the ladle the copper is spread a little, so as to increase the diameter of the ladle 0.2 inch: the corners are rounded with a radius of from 2 inches to 3.5 inches. To stiffen the ladle, the copper is *planished* after being bent and brazed. The ladle is attached to the head by 6 to 10 *copper nails*, 1 inch long, driven in two rows around the body about 1 inch apart.

Worms, (iron :) *Socket, neck, branches.*

Worms are made of two sizes.

DIMENSIONS.					Sea coast, garrison and siege.	Field.
					Inches.	Inches.
Length of socket and neck	-	-	-	-	5.5	5.5
Length of one branch from neck to point (developed)	-	-	-	-	16.	13.
Depth of socket	-	-	-	-	4.5	4.5
Exterior diameter of socket at top	-	-	-	-	1.75	1.5
Diameter of neck	-	-	-	-	0.8	0.7
Thickness of the iron of the socket	-	-	-	-	0.125	0.125
Diameter of branches at the neck, (tapering to a point)	-	-	-	-	0.6	0.5
Length of socket and worm complete	-	-	-	-	9.5	9.
Diameter of worm complete, (exterior circle)	-	-	-	-	4.	3.
Size of iron for worms,	length	-	-	-	7.	6.
	width	-	-	-	3.	3.
	thickness	-	-	-	0.5	0.5
Weight of worm	-	-	-	lbs.	1.75	1.5

The staff is pointed to fit the conical form of the socket, driven in hard and fastened by 2 *iron rivets* 0.25 inch diameter.

STAVES for implements; *body, tenon.*

Staves are generally made of tough ash; if of pine or cedar, they should be in two pieces glued and serewed together, and the diameter should be 0.25 inch greater than that given in the table.

The diameter of the tenon is 0.25 inch less than that of the staff; its length, $\frac{2}{3}$ of that of the head into which it is inserted.

For field guns, siege howitzers and mortars, the rammer and sponge heads are on the same staff; for other pieces, on separate staves.

For Coehorn mortars, the body of the staff forms the rammer and sponge heads.

DIMENSIONS OF STAVES.	SIEGE, GARRISON AND SEA COAST GUNS.					Sea coast how- itzers.		Siege howitzer.	FIELD.		MORTARS.		
	42	32	24	18	12	10-in.	8-in.		12-pdr. gun and 24-pdr. howitzer.	6-pdr. gun and 12-pdr. howitzer.	13 in. and 10-in. heavy.	10 in. light, 8-in. and stone mortars.	Coehorn, 24-pounder.
Length, including the tenon, { for sponge for rammer for ladle for worm Diameter	In. 125.33 125.66 125.66 123 1.75	In. 125.23 125.86 125.86 123 1.75	In. 125.33 126.06 126.06 123 1.75	In. 125.33 126.23 126.23 123 1.75	In. 125.50 125.66 126.46 123 1.75	125.33 125.66 - - 1.75	95.33 95.86 - - 1.75	52 - - - 1.5	82.16 - 82.5 1.5	67.67 - 67.5 1.5	39.16 - - 1.5	29.67 - - 1.5	18 - - 1.5
	128 lbs.	128 lbs.	128 lbs.	128 lbs.	128 lbs.	128 lbs.	98 lbs.	56 lbs.	87 lbs.	72 lbs.	44 lbs.	34 lbs.	18 lbs.
	10.25 9.75 13.75 7.5	10 8.4 13.15 7.5	9.65 8.15 12.4 7.5	8.7 8 10 7.5	7.8 7.35 7.8 7.5	10.25 9.75 - -	8.5 7 - -	3.7 - -	5.4 - 4.25	4.2 - 3.6	3.2 - -	2 - -	0.8 - -
	-	-	-	-	-	-	-	-	-	-	-	-	-
FINISHED IMPLEMENTS.													
Length of each - -	-	-	-	-	-	-	-	-	-	-	-	-	-
Weight of { sponge and staff rammer and staff ladle and staff worm and staff	-	-	-	-	-	-	-	-	-	-	-	-	-

For other cannon than those described in *Chap. 1*, staves may be made of such a length that the finished implement shall be 18 inches longer than the bore of the piece.

The scantling of timber for implements should be from 0.25 inch to 0.5 inch greater than the greatest diameter of the implement for which it is intended. In the length of plank for staves an allowance of about 3 inches should be made, for seasoning checks, &c.

MANŒUVRING HANDSPIKE, for siege, garrison and sea-coast carriages and for gins, (hickory, young oak.) Whole length 83 inches; length of the *square* 13 inches; *chamfered part* (8 square) 12 inches; the remainder round. Diameter at the upper end 1.8 inch—upper end of the square 3 inches—lower end 2.36 inches—Weight 11 lbs.

TRUCK HANDSPIKE, for casemate carriages, (wrought iron;) whole length 42 inches—*point*, conical, 4 inches; *body* (8 square) 12 inches; the remainder, round. Diameter at the ends 1.1 inch—body 1.4 inch—Weight 19 lbs.

TRAVERSING HANDSPIKE, for casemate chassis, (hickory, young oak;) whole length 32 inches—length of the square 17 inches; length of the tenon that enters the socket, 2.5 inches. Diameter of the small end 1.75 inch—upper end of the square 2.5 inches—2 *friction plates*, each held by 9 *nails*. Weight 6 lbs. These handspikes are not made for the casemate carriages of the pattern of 1840.

SHOD HANDSPIKE. Upper end 1.75 inch diameter; the lower end of the round part, 2.5 inches—square 2.5 inches by 3 inches. The end rounded on one side, and shod with an iron *claw shoe* fastened with 3 *rivets*. Length of round part 4 feet—square 14 inches. It is particularly useful in the service of mortars and of casemate and barbette carriages.

TRAIL HANDSPIKE, for field carriages; (hickory, young oak,) whole length 65 inches—the *large end* rounded hemispherically, diameter 2 inches; the *body* cylindrical, diameter 2.75 inches—the *small end*, diameter 1.5 inch—the *stop*, iron 0.6 inch square, projecting 0.4 inch; distance from the large end to the farthest side of the stop 11 inches; the stem clinched in the wood and filed down smooth—the *strap*, iron 0.6 inch square, fastened by 1 *rivet*; the middle of it 9.5 inches from the small end—the *ring*, round iron 0.3 inch diameter. Weight 4.625 lbs.

SPONGE AND RAMMER FOR MOUNTAIN HOWITZER. The *head* like that of other sponges, length 5 inches; diameter 2.5 inches—the *staff*, pierced in the middle part with two holes 0.4 inch diameter, 1.5 inch apart; the *rammer head* countersunk—1 *band* for rammer head, copper, fastened by 3 *nails*—1 *eye*

staple, near the rammer head, riveted on a *burr* countersunk in the staff—Length of the staff in the clear 40 inches; diameter at the end 1.65 inch; in the middle, 2 inches. Weight 4.75 lbs.

HANDSPIKE FOR MOUNTAIN HOWITZER, 43 inches long, of the same size with the sponge and rammer staff and pierced like it with two holes to receive a loop of 1 inch rope—1 *strap ring* at one end, let into the wood and fastened by 2 *rivets*. Weight 3.25 lbs.

LINSTOCK; (ash, elm, oak) length 36 inches—mean diameter 1.5 inch—a hole 0.75 inch diameter 1 inch below the top; the other end pointed and shod with iron. Weight 1.15 lbs.

PORT FIRE STOCK. The *portfire socket* made of a piece of sheet-iron 0.1 inch thick, 2 inches long, rolled on a mandril 0.65 inch diameter, with a circular plate in the bottom of the socket; a *nut* near the top for a thumb-screw; the lower part forms the *stock socket*, in which the stock is secured with 1 *rivet*—the *thumb-screw*, to hold the port-fire; the end riveted inside; the *hook*, 8 inches from the top to hang in the loop of the port-fire case—the *stock* (ash, elm, oak) 22.5 inches long; mean diameter 1 inch; whole length 24 inches. Weight 0.437 lbs.

PASS BOX, (white pine, 0.75 inch thick)—interior dimensions 6.8 inches square by 14 inches long; one side turns on 2 *hinges* and is fastened with a *catch*—a wooden *handle* set diagonally on one end. Weight 6 lbs.

BUDGE BARREL, for use in forts and batteries; 16 *staves* (oak) 0.4 inch thick—*bottom* (oak) in 1 or 2 pieces 0.4 inch thick—4 *hoops* (copper) of 2.25 lbs. to the square foot,) 1.1 inch wide, and confined to the barrel by 5 *rivets* each; they are joined by 2 *rivets*, or brazed together—height of barrel, 20 inches; exterior diameter at ends, 13 inches; at bilge 15 inches—*cover*, (bag or havresack leather) 18 inches high and 40 inches wide, secured to the barrel under the upper hoop by 4 *rivets*, and the 5 *rivets* through the hoop—the *cord*, (or braided leather) 0.7 inches round, 30 inches long, passing through holes in the cover at 1.5 inch from the top, to draw the mouth together; the ends of the cord may pass through a *cap* or *hood* 9 inches deep, sliding on the cord. Weight of barrel complete 13.75 lbs.

GUNNER'S HAVRESACK: (bag hide) 2 *sides* 13 inches high, 13 inches wide at bottom, 14 inches at top of flap—end and bottom *gussets* 5 inches wide—*flap* 8 inches deep, with a *strap* 7 inches long passing through a *buckle* sewed to the front side—*belt*, 1.5 inch wide, one part 12 inches long, with a *buckle and loop*, the other 36 inches long. Weight 1.75 lb.

PORT FIRE CASE: (sole leather,) to contain 12 port fires; length of *case* 15.6 inches; interior diameter 2.75 inches—*cover*, 5.8 inches high, with two *loops* for the belt—1 *loop* on the cover and 1 on the case for port fire stock—*belt*, 1 inch wide with a *buckle* and *strap* like that of the haversack, and a *pocket* for the port fire cutters; length of long strap 53 inches, short strap 26 inches; the straps are sewed on the case so as to be below the top when the case is empty. Weight 1.5 lb.

TUBE POUCH: the sides 4.25 inches high, 7.25 inches long—2 *ends* 0.9 inch wide at bottom, 2 inches at top—the inner *cover*—the *flap*, 8 inches deep with its *strap*, and brass *button* attached to the bottom of the pouch—2 *loops* for the belt to pass through—the *belt*, 1.37 inch wide and 42 inches long, with a *buckle* and *loop* at one end. The priming wire and gunner's gimlet are carried with the tube pouch in the loops, being attached to one of the loops by a twine. Weight 1 lb.

PRIMING HORN: The *horn*, about 13 inches long, 3 inches diameter at the bottom, and 1 inch at the neck—the *bottom* (poplar or ash) 1 inch thick hollowed out on the exterior for the convenience of filling, having a hole 0.75 inch diameter, with a *screw plug*, in the centre—the *stopper*, a conical piece of wood, mean diameter, 0.4 inch. Instead of the stopper the horn may have a *brass mouth piece*, closed by a *valve*, which is held fast by a *spring*. The *strap* (leather) 1 inch wide and 48 inches long sewed to the neck of the screw plug in the bottom, and to the neck of the horn or to a ring on the brass mouth piece. The horn should contain at least 1 lb. of powder. Weight 0.5 lb.

PRIMING WIRE. Iron wire 0.15 inch diameter, formed with a ring 2 inches diameter at the head, and pointed; length of stem, for siege and garrison guns 14 inches; weight 2 oz: length for field guns, 8 inches; weight $\frac{1}{2}$ oz:

GUNNER'S GIMLET, like the priming wire, terminating in a gimlet point.

VENT PUNCH—the *body* (steel wire) 0.175 inch diameter, 4.3 inches long—*head* 0.175 inch thick, 1 inch long, 1 inch wide, with a hole 0.2 inch diameter, at 0.5 inch from the top.

THUMBSTALL; (buckskin,) *cushion*, stuffed with hair 2.5 inches diameter, 1 inch thick—the *upper part* 4 inches long—the *string* 12 inches.

PORT-FIRE CUTTER; (Shears.) *Blades* (steel) 4.37 inches long with a notch 1 inch long and 0.4 inch deep in one of them, 1 inch from the joint—*handles* with bows 2 inches by 1 inch—whole length of shears 7 inches. Weight 0.437 lbs.

TANGENT SCALE; (brass) lower side 0.5 inch thick, cut to fit the base ring

of the piece ; upper edge cut into notches for various elevations from $\frac{1}{4}$ to 1 degree each.

CANNON LOCK (percussion)—*Hammer* : (brass :) *shank* 0.875 inch diameter, 3 inches long, with two holes for the *lanyard* and *pivot* ; *head* pointed with a *steel plug* screwed in ; *cams* to move the slide—*supporter* : (brass) *studs* for the hammer pivot ; *cushion* for the head of the hammer ; *eye* for the lanyard—*pivot screw* and 2 *side screws*—*slide* to cover the vent, (iron)—*Lanyard*, (cord 0.375 inch diameter) 12 feet long. Weight of lock for field guns 3 lbs. ; sea coast, 7 lbs.

CANNON LOCK, (Hidden's patent.)—*Hammer* : *shank* (soft steel ;) *head* hardened with a countersunk hole in the back for the *stuffing*, to receive the shock in flying off from the vent—*pulley* (brass) fixed to the end of the shank, for the lanyard to pass over—*box*, or cover for the pulley—*pivot screw*—*supporter*, fixed to the lock piece of the gun by 2 *side screws*, or if there is no lock piece, secured by a *brass band* passing round the gun and tightened by a *screw* underneath. Weight 3 lbs.

FUZE SETTER ; (oak or elm wood, or brass) *the handle*, upper end slightly rounded—the *cup* 2.1 inches diameter for large shells, 1.5 inch for field howitzers ; depth 0.3 inch ; whole length 5 to 6 inches—Weight : brass, large 2.1 lbs. small 1.6 lb. : wood, large 0.75 lb.—small 0.5 lb.

FUZE MALLET ; (dog wood) in one piece ; *head* 5.5 inches long, 4 inches diameter—*handle* 7.5 inches long, 1.25 inch diameter—Weight 2.75 lbs.

FUZE SAW ; (tenon saw,) 10 inch blade—Weight 0.625 lb.

FUZE RASP ; 12 inch wood rasp—Weight 0.875 lb.

FUZE AUGER, for boring out the composition to any required depth : *bit* 0.2 inch diameter sliding in a brass *socket* graduated to 10ths of an inch, and held by a thumb screw in the side—*handle*, box, black walnut, or other hard wood—Weight 0.312 lb. It is chiefly used in firing spherical case shot.

FUZE GIMLET ; common $\frac{1}{4}$ inch gimlet : used for boring across the composition instead of sawing off the fuze.

SHELL-PLUG SCREW ; (iron) *stem* 3 inches long, cut with a deep, sharp thread—*eye* 2 inches diameter. Weight 0.437 lb.

FUZE EXTRACTOR ; (iron)—the *frame* consisting of 2 uprights 0.8 inch by 0.4 inch, resting on a beveled circle 4.5 inches interior diameter, and united above to form a collar for the *extracting screw* which is 0.6 inch diameter and 6 inches long to the shoulder ; this screw is turned by means of a *handle* 6 inches

long in a *nut* 3.5 inches long, to which 2 *branches* with curved claws are suspended: the claws are pressed against the head of the fuze or the plug screw by means of a *pinching screw* 0.6 inch diameter and 4 inches long to the shoulder, passing through a collar in one of the branches and working in a thread in the other, being turned by a *handle* 5 inches long—Whole weight 9 lbs.

This extractor will serve for shells of any calibre from a 12 pdr. upwards.

GUNNER'S QUADRANT; (wood or brass) a graduated *quadrant* attached to a rule 12 inches long, with a *plumb line* or *spirit level*—Weight, wood 1 lb.; brass, 2 lbs.

MAUL, for driving pickets; *head* (elm or hickory) 6 inches diameter, 8 inches long—*handle* (ash) $1\frac{1}{2}$ inch diameter, 24 inches long, with an iron band on each end, 1 inch wide, $\frac{1}{4}$ inch thick—Weight 10 lbs.

POINTING WIRE, for mortars; (iron wire) 0.175 inches diameter, 20 inches long—Weight of 3——, 0.25 lb.

QUOIN for mortars—Weight 4 lbs to 10 lbs.

QUOIN for casemate carriages—Weight 32 lbs.

ELEVATING MACHINE for casemate carriage—Weight 116 lbs.

CHOCK for casemate carriage; small wedge with a handle on one side.

PLUMMET, for mortars—*line* and *bob*: Weight 1 lb.

SCRAPER, for do. (iron) *handle* 0.5 inch by 0.3 inch square, 27 inches long—one end formed like a *spoon*, the other, a *scraper*—Weight 2.3 lbs.

SPATULA, for mortars (ash or hickory,) *handle* 16 inches long—*blade* 6.5 inches—*square end* 3 inches long—Weight 12 oz.

SPLINTS; (white pine) 6 inches long, 0.25 inch thick at the large end, 1 inch wide—Weight of 10, 0.3 lb.

SAND BAG, for cleaning chamber of mortars—(tow cloth) length empty 32 inches; breadth 14 inches—weight 0.6 lb.; length filled 27 inches—breadth 12 inches—thickness 7 inches.

GUNNER'S SLEEVES, for do. (serge or flannel.)

BASKET, for mortar implements—of strong wicker work, 18 inches in diameter, 12 inches deep—Weight 5 lbs.

VENT COVER, for field guns (leather) 6 inches long, 4 inches wide, with a *copper pin* riveted to it, 0.15 inch diameter, and 2 inches long—2 *straps*, 1 inch wide, 25 inches long, with *buckles*—Weight 0.5 lb.

In fixed batteries the vent cover may be of sheet lead, or a little pent roof of wood.

TARPAULINS, for barbette carriages, (painted canvass;) for form and dimensions see *Plate 9*, and for manner of painting, see CHAP. 13.

TOMPIONS, for 8-inch siege howitzers and mortars.

BROOM, for mortar batteries, (hickory or birch.)

SHELL HOOKS; (iron) 2 *branches* 0.5 inch diameter, in shape of an *S*, joined by a *rivet*; upper end of the branches connected by 2 *small rings* 1.25 inch diameter, and 1 *large ring* 3.4 inches diameter: straight *points*, to insert into the ears of the shell 0.5 inch diameter, 0.75 inch long—whole length of branches 12.47 inches—Weight 2 lbs.

TOW HOOK; (iron,) *handle* 0.4 inch diameter; *hook* 1 inch—the other end forms a *hammer* 0.6 inch diameter, 2 inches long. Weight 0.625 lbs.

Used for unpacking ammunition chests.

FUNNEL; (copper or tin) diameter of *funnel* 3.3 inch—diameter of *pipe* 0.7 inch—length of pipe 2 inches—Weight 0.187 lbs.

POWDER MEASURE; (copper) to hold 8 oz.—diameter and height 2.673 inches, weight 3½ oz. For dimensions of other powder measures, see CHAP. 9.

PROLONGE; hemp rope of 4 strands; diameter 1.1 inch, on one end, a *toggle* and 3 *round links* in a *thimble*—on the other end, a *hook* and *thimble*—from the end of the hook to the centre of 1st *ring*, 2.7 inch; from centre of 1st to centre of 2d *ring*, 8 feet; from centre of 2d *ring* to end of *toggle*, 16 feet.—Whole length of *prolonge* 26 feet, 7 inches—the *toggle* of round iron 0.75 inch diameter, 7.5 inches long, with an eye in the centre—*toggle rings* of 0.5 inch round iron; the ring that enters the *thimble* is 3 inches, the other two 2.5 inches exterior diameter—*hook* 6 inches long; *eye* of 0.5 inch round iron, exterior diameter 2.5 inches; body of *hook* 0.75 inch diameter, tapering to a point—*thimbles* 1.1 inch interior diameter—*prolonge rings* of 0.6 inch round iron, 4.2 inch exterior diameter; the concave flattened part that is lashed to the rope is 2 inches long, lashed with *cord* 0.175 inch diameter. Weight of *prolonge* 14.25 lbs.

SPONGE BUCKET; (sheet iron 0.1 inch thick;) the *float*, of poplar 6 inches diameter, put in before the cover is fastened; it has a *cross-bar* and *handle* of iron, and a *chain* fastened to the top of the bucket—the *handle*, round iron, 0.4 inch thick—the *link*, 0.75 inch square iron—the *toggle* round iron 0.35 inch diameter—the *ears* 1.5 inch by 0.4 inch, fastened with 3 rivets 0.25 inch thick—the

top and *bottom* are turned over to form hoops 1 inch wide round the sides to which they are riveted—height 9 inches, diameter 8 inches—Weight 6.5 lbs.

TAR BUCKET, (sheet iron 0.1 inch thick)—2 *ears* 3 inches by 1 inch fastened with 3 *rivets* each.—The *top* has an opening 3.5 inches in diameter with a *cover* turning on a pivot and held fast by a stud; the border of the top goes over the bucket: the *handle* consisting of 2 *chains*, each of 6 *links* and 1 *ring* made of iron wire 0.2 inch thick, connected by a *large ring* 1.4 inch diameter, which forms the top of the handle—the top, bottom and sides are riveted—height 8 inches; exterior diameter, 7.2 inches—Weight 5 lbs.; contains 9 lbs. of grease.

SHOVEL—*blade* sheet iron 0.1 inch thick, pointed with steel—length 12 inches; width at top 10.5 inches—length of the *socket* above the blade 6 inches—*handle* (ash) 1.5 inch thick at bottom, and 1.25 inch at top; whole length above the socket 30 inches—*ring*, 1.5 inch diameter secured by a *strap* to the handle at 4 inches from the upper end—Weight of shovel and handle 4.15 lbs.

PICKAXE; iron, pointed at both ends with steel—length of each blade 6.5 inches; width of edge of axe 3 inches—the *eye* oval, 2.75 inches by 1.75 inch; 2.5 inches deep in the centre, 1 inch at the blades—*handle* (hickory) about 1.5 inch by 1.25 inch and 40 inches long—Weight of *pickaxe* with handle 5.125 lbs.; of handle 1.5 lbs.

FELLING AXE—*Blade* with steel edge, length 7.25 inches; width of top 3.5 inches, of edge 4.75 inches; thickness at top 0.75 in. at the eye 1.25 inch; size of the eye 2.25 inches by 0.75 inch—*handle* (hickory) 27 inches long. Weight of axe and handle 5.5 lbs.

BILL HOOK; (iron with steel edge)—*blade*, whole length 8.25 inches; width in the middle 3 inches, towards the hook and near the shank 2.7 inches; thickness near the shank 0.3 inch, elsewhere 0.16 inch—*hook* 1 inch long—*shank* 8 inches long, 0.8 inch wide by 0.3 inch thick at the blade—*handle* (hickory) 7.5 inches long.—Weight of blade and handle, 4 lbs.; handle, 5 oz.

DRAG ROPE; 4 inch rope 28 feet long, with a *thimble* worked in a loop at one end, and a *thimble and hook* at the other end—6 *handles*, wood, 12 inches long, 1.5 inch in diameter, fastened in the rope at the distance of 4 feet apart, and at the same distance from the ends of the rope—Weight 13 lbs.

MEN'S HARNESS; 4 inch rope 18 feet long, with *thimbles* and a *hook* like the drag rope—instead of handles 10 *loops* made of strips of bag leather 5 feet long, 2.75 inches wide, are fastened to the rope in pairs, each pair being secured in place by two knots worked in the rope; the first pair of loops at 3 feet from the hook; the others, at a distance of 3½ feet apart—Weight 23 lbs.

Preservation and arrangement in store.

Implements collected together according to kind and calibre, in a dry place, arranged on shelves or racks, in bundles or bunches, or in boxes, according to their nature, with marks and labels showing the kind and number of the articles.

Sponges, rammers, ladles and worms complete, placed on pins in a vertical frame, or suspended vertically or horizontally by racks or hooks, from the joists, supported so as not to bend.—When in separate parts, the *heads* piled on shelves or on the floor, and the *staves* tied up in bundles, according to kind and calibre.

The *woollen sponges* should be preserved from moths by means of camphor, pepper, &c.

Handspikes, in square piles, heads and points alternating.

Leather Equipments—hung on pins or hooks, in dry and cool rooms.

All wood painted, except tool handles—Iron either painted or oiled—See CHAPTER XIII.

Entrenching and miner's tools, arranged in piles, the iron coated with varnish. See CHAPTER XIII.

CHAPTER FIFTH.

ARTILLERY HARNESS.—(Plate 10.)

The peculiar construction of the stock trail carriage requires a harness differing in some respects from that in general use in the country.—The limber having no sweep bar, the pole must be supported directly by the wheel horses, and to diminish its weight, as much as possible, the *double tree* is dispensed with and the traces of the leaders are attached to those of the wheel horses.

Black leather (harness or bridle leather) is the material used for the leather parts not otherwise designated; it should be well tanned and dressed, and of the best quality, the strongest leather being selected for the parts most liable to strains: it is sewed with strong waxed thread, in double stitch, with about eight stitches to an inch; the seam along an edge should be 0.15 inch or 0.2 inch, from the edge; the awls should be small and the thread large (the reverse is apt to be the case) and the ends of the thread should be well secured before being cut off. *Straps* and other pieces which have *buckles* or iron *loops* attached to them should be doubled in a length equal generally to twice their width to receive the buckle or loop, which is held by 2 seams; the doubled end is shaved down. The *standing leather loops* are placed near the buckles; their ends are shaved down, brought together and fastened between the two parts of the strap where it is doubled.

The *tongue holes* are made with a *punch* of a size to correspond with that of the tongue; their distance apart is generally equal to the width of the strap, and the first hole is at double that distance from the end of the strap which is a little thinned and diminished in width to facilitate its entrance into the buckle.

The *hames*, *buckles*, *hooks*, *rings*, *chains*, &c., are of wrought iron *japanned* (black;) the *bits* and *stirrups* are of iron *tinned*: the buckles are all made with *rollers*.

In the inspection of harness a reasonable allowance is made with regard to the dimensions, according to the degree of accuracy usually found in harness making.

NOMENCLATURE.

NOTE.—A *layer* is a piece of leather sewed upon another piece, to strengthen it.

A *chape* is a piece used to fasten a buckle or loop to a strap, &c.

A *billet* is a strap which enters a buckle.

A *safe* is a piece of leather placed under a buckle, &c. to prevent it from chafing.

The Harness may be divided into three parts: the *head gear*, the *saddle*, and the *draught harness*.

Head Gear.

The head gear is made of strong black bridle leather; none of it should be thinner than 0.1 inch.

Halter.

The *crown piece*—2 *cheek straps*, each with 1 *buckle*, 1 *standing* and 1 *sliding loop*—the *brow band*—the *nose band*—2 *chin straps*—the *throat strap*—these parts are all $1\frac{1}{4}$ inch wide, and they are connected together by 2 *cheek buckles* and by 3 rectangular *iron loops*, $1\frac{1}{2}$ inch by $1\frac{1}{4}$ inch—the *shank* or *hitching strap*, and *billet*, $1\frac{1}{4}$ inch wide, with 1 *buckle* and 1 *standing loop*—the *throat lash*, 1 inch wide, with 1 *buckle*, 1 *standing* and 1 *sliding loop* on the left side; the throat lash passes through the loops of the brow band, on top of the crown piece, and through a loop in the upper end of the throat strap.

Bridle for the near horse.

The *crown piece*, $1\frac{3}{4}$ inch wide at the top, cut into two parts so as to form the *throat lash* $\frac{3}{4}$ inch wide, and 2 *billets* 1 inch wide for the cheek buckles: length between the ends of the billets 30 in., of the throat lash 42 in.—1 *buckle* and 1 *standing loop* for the throat lash—the *brow band* 1 in. wide, 16 in. long, formed into a loop at each end to receive the crown piece—2 *cheek straps* 1 in. wide, each with 1 *buckle* and 2 *loops* at the upper end, and sewed into a rectangular *iron loop* at the lower end—2 *billets* for the bit, 1 in. wide and $9\frac{1}{2}$ in. long, by means of which the bit is attached to the loops on the cheek pieces of the bridle: it may be attached to the head stall of the halter by the same means, thus forming a *watering bridle*—the *reins* 1 inch wide, in two parts 42 inches and 60 inches long respectively; the short part is on the near side and has a *buckle* and 2 *loops*, to receive the long rein; each part is attached to the bit by a *billet* 1 inch wide and 9 inches long, with a *buckle* and 2 *loops*.

THE BIT: a *curb*, consisting of the *bar*, with a *port mouth*; 2 *cheek pieces*, straight, with an eye at the upper end of each for the billet by which it is attached

to the head stall, and 2 eyes for the reins, one at the bottom and the other at the height of the bar, thus allowing the reins to be shifted at pleasure—the *curb chain*, fastened by a hook to the left cheek piece and by an *S* to the right—the *lower bar*, joining the lower ends of the cheek pieces. The width of the bits between the cheek pieces varies for three sizes, $4\frac{5}{8}$ in. $4\frac{7}{8}$ in. and $5\frac{1}{8}$ in.—In a large number there should be about one-fifth of each of the extreme sizes.

Bridle for the off horse.

The leather parts are the same as in the bridle for the near horse, with the addition of the *coupling strap*, 1 in. wide, 84 in. long, with a *buckle* and *billet*; it passes through both rings of the bit, forming a curb strap.

THE BIT: a snaffle, consisting of 2 *mouth pieces* hooked together, and 2 *rings* with *cheek pieces*.

Driver's Saddle.

Tree.

WOODEN PARTS, (beech.) The *pommel*—the *cantle*—2 *side bars*, notched into the pommel and cantle; these parts are covered with canvass glued on, and painted: length from pommel to cantle 16 inches—the form of these parts is such that when the finished saddle is placed on the horse there may be room for the hand to enter between the pad and the horse's back.

IRON PARTS. 2 *pommel plates*, one above, the other below, fastened by rivets passing through both—1 *cantle plate*, riveted to the cantle and side bars—2 *loops* $1\frac{1}{4}$ inch wide; one let into the front of the pommel for the collar strap; the other in rear of the cantle, for the crupper—2 *stirrup bars*, $4\frac{1}{2}$ inches long, one end riveted to the point of the pommel, the other to the side bar, with a middle *stay* riveted also to the side bar—4 *loops* 1 inch wide secured by sheet iron *chapes* riveted to the tree, 2 of them on the pommel 6 inches below the top, for the holster straps; the other two on the cantle 4 inches from the crupper-loop, for the cloak straps—2 *stirrups*, $4\frac{1}{2}$ inches wide and $4\frac{1}{4}$ inches high inside.

THE SEAT: formed with *hemp webbing* stretched on the tree and tacked on in the usual way.

Leather Parts.

The *cover*, black upper leather—the *stuffing*, deer's hair—2 *skirts*, $24\frac{1}{2}$ inches long and $15\frac{1}{4}$ inches wide, the lower corners rounded—the *pad* made of sheepskin, lined with strong *russia linen*, faced with black upper leather and stuffed with deer's hair (20 oz.;)—1 *billet* $1\frac{1}{4}$ inch wide, 8 inches long, fixed to the

upper loop on the pommel, for the collar strap—2 *girth billets* and 2 *billets* for the side pipe straps, $1\frac{1}{4}$ inch wide and 15 inches long, fastened to the stirrup bars behind the middle stay.—2 *stirrup leathers* $1\frac{1}{2}$ inch wide, 56 inches long, each with a *buckle* and 2 *loops* placed on the thin end where it is doubled and stitched in a length of 8 inches, so that the stirrup bears on the double part; the buckle is brought down near the stirrup to facilitate the adjustment of the length.—*Girth*, (black leather) $2\frac{1}{2}$ inches wide, 45 inches long, with a *buckle* $1\frac{1}{4}$ inch wide and 2 *loops*, attached to the ends by layers.

The pommel and cantle are bound with sheet brass.

Valise Saddle, for the off horse.

The *tree*, made in a similar manner to that of the driver's saddle, omitting the *stirrup bars*; length from pommel to cantle 9 inches—1 *hook* for the bearing rein; the shank passes through the head of the pommel and is riveted underneath—4 *iron loops*, for the valise straps, 2 of them riveted to the side bars and 2 to the cantle—the *pad*, similar to that of the driver's saddle—2 *skirts*, 10 inches wide 15 inches long, oval at the bottom—1 *billet* for the girth $2\frac{1}{2}$ inches wide, 23 inches long, sewed to the near skirt—the *girth*, $2\frac{1}{2}$ inches wide, 39 inches long, sewed to the off skirt—1 *buckle* and 1 *loop* for ditto—2 *billets* for the front pipe strap, $1\frac{1}{4}$ inch wide and 18 inches long, pass through the skirts 2 inches below the side bar of the tree and are nailed to the bar—2 *loops*, for the collar strap and crupper, as in the driver's saddle—1 *crupper strap*, $1\frac{1}{4}$ inch wide and 5 inches long, is sewed to the loop on the cantle and has an *iron loop* sewed to the other end, in order that the same crupper may answer for either saddle.

Valise,

Made of black bridle leather, is $18\frac{1}{2}$ inches long, $7\frac{1}{4}$ inches diameter, the bottom flat; it is lined with *cotton ticking*—2 *valise straps* 1 inch wide, 30 inches long—2 *buckles* and 4 *loops* for ditto.

Whip.

Stock, (hickory)—*cover* and *thong*, braided leather—*loop* for the hand.

Leg Guard.

The *body*, (sole leather,) 17 inches wide; outside part $20\frac{1}{2}$ inches long; inside, 13 inches long—2 *layers* 2 inches wide, 7 inches long, stitched on the ends of the outside part—*under strap*, $3\frac{1}{4}$ inches wide, 13 inches long, sewed to the bottom part, to go under the foot—4 *leg straps*, $3\frac{1}{4}$ inches wide, 24 inches long, fixed to the body of the leg guard—4 *buckles* and 4 *loops* for ditto—1 *plate* (iron) 0.1 in. thick, 2 in. wide, 12 in. long, fastened on the outside of the body by 5 *rivets*.

Draught Harness.

Collar.

The rim, (bridle leather stuffed with uncut rye straw—the belly (upper) leather) stuffed with straw cut in pieces not more than $\frac{1}{4}$ in. long—1 buckle and billet, with a pad at the top of the collar—the collars are made of 2 sizes, 17 and 20 in., (measured inside,) which by means of the buckles and billets may be varied to any size between 17 and 22 in. When the stuffing of the collar becomes too hard by service it may be softened by moistening it and beating it with a wooden mallet.

Hames. (Iron.)

2 branches—2 joint loops for trace tugs, fastened by bolts riveted in studs on the branches—2 rollers for ditto—2 links (oval) for the breast strap, welded into eyes in the lower ends of the bolts—2 rings welded in the eyes in the upper ends of the branches—1 clasp, hooked into the eyes at the lower end of the hames and made fast to the off branch—chain and toggle for the pole yoke ring,

2 safes, 7 in. long and 7 in. wide, fastened under the joint loops, to protect the collar—2 trace tugs, $1\frac{3}{4}$ in. wide, 7 in. long, made of several layers so as to be $\frac{5}{8}$ in. thick, stitched in three rows, and fastened in the joint loops—2 loop rings for ditto, through which the traces pass.

2 trussing straps, passing round the upper part of the branches and secured by 2 sliding loops, for trussing up the harness—2 buckles and 2 standing loops for trussing straps.

1 hames strap, 1 in. wide, 18 in. long, for fastening the branches of the hames together at the top—1 buckle and 2 loops for ditto—1 collar strap $1\frac{1}{4}$ in. wide, 14 in. long; 1 buckle and 1 loop for ditto; the collar strap is passed round the hames strap and buckled to the billet attached to the pommel of the saddle, to keep the collar in place.

Two Traces : (each.)

1 trace rope, white $2\frac{3}{4}$ in. rope, 9 feet long, made with four strands of the best quality of Russia hemp; an eye or loop $1\frac{1}{4}$ in. diameter is formed at one end in twisting the rope.

1 sheath, (upper leather) covering the loop and the front end of the trace rope for a length of 30 in.—1 trace hook—1 safe, 4 in. diameter—the ring of the hook is caught in a slip knot formed by passing the end of the rope through through the loop, and the safe is placed against the knot, to protect it from the friction of the trace tug ring through which the rope is passed.

1 trace chain, 10 in. long, formed by 5 links of iron 0.3 in. thick; the last

link is egg shaped and covered with leather, to receive the trace rope ; the rope is fastened by a knot, the end passed through a slit in the rope behind the knot and lashed down with marline twine.

The length of the wheel horse trace, from the hames to the hook on the splinter bar, is 7 feet ; the length of the leading horse trace, from the hames to the ring of the wheel horse trace, is 9 feet 6 inches.

Two Side Pipes: (each)

1 *pipe*, the leather for which is 27 in. long and 9 in. wide ; the seam is worn uppermost, to protect it from the friction of the trace and breast strap which pass through it—2 *cuffs*, $2\frac{1}{2}$ in. wide, covering the ends of the pipe—1 *iron loop* $1\frac{1}{4}$ in. wide, placed on the under side of the pipe, 6 in. from the front end, and secured there by a *leather chape* sewed to the pipe—1 *billet* for the belly band, $1\frac{1}{4}$ in. wide, and $14\frac{1}{2}$ in. long, sewed to the loop on the near pipe—the *belly band* $1\frac{1}{4}$ in. wide, 31 in. long, sewed to the loop on the off pipe—1 *buckle* and 1 *loop* for ditto—1 *leather chape*, sewed on the outside of the pipe, $2\frac{1}{2}$ in. from the rear end, to keep the rear pipe strap in place.

4 *tugs for pipe straps* $1\frac{1}{4}$ in. wide, 16 in. long, passing round the pipe, the front ones through the loops, and the rear ones through the chapes—4 *buckles* and 4 *loops* for ditto—the buckles of the front tugs receive the billets of the *loin straps*: two straps support each pipe.

1 *loin strap*, $1\frac{1}{4}$ in. wide, 44 in. long ; the ends buckle into the tugs on the rear end of the side pipe—a *layer* 6 in. long is sewed under the middle of the loin strap, leaving an opening of 2 in. through which the back strap of the crupper passes.

Crupper.

The dock, the leather for which is cut $3\frac{1}{2}$ in. wide and 14 in. long ; the edges are turned into the centre and then doubled and rounded, without stuffing—2 *buckles* $\frac{7}{8}$ in. wide and 2 *loops* for ditto—the *body*, $1\frac{3}{4}$ in. wide, 20 in. long, split at the rear end into 2 *billets* 10 in. long, $\frac{7}{8}$ in. wide, which are buckled to the dock ; the other end has a *buckle* and 4 *loops* for the billet of the back strap ; a *layer* $1\frac{1}{4}$ in. wide, 10 in. long, is sewed on this part, leaving an opening of 2 in. at the distance of 4 in. from the front end, for the hip straps to pass through—the *backstrap*, $1\frac{1}{4}$ in. wide, 31 in. long ; the rear end is inserted between the layer and the body of the crupper as far as the opening for the hip straps, and a short *layer* is inserted also behind the opening, to protect the seams from the rubbing of the hip straps ; the front end of the back strap passes through an opening in the loin strap and through the crupper loop of the saddle and returns to the

buckle on the body of the crupper—a *sliding loop* confines the back strap to the crupper loop.

Breeching.

The *breech strap*, made of strong leather, 42 inches long, $2\frac{1}{2}$ inches wide—1 *layer*, 42 inches long, $1\frac{3}{4}$ inch wide—2 *buckles* for do., $1\frac{3}{4}$ inch wide and $2\frac{1}{2}$ inches long—6 *loops* for do.—both the layers of the breech strap pass over the bar of the buckle and are turned back 4 inches and sewed down—2 *iron loops*, placed one on each side, 13 inches from the centre of the breech straps; they are fastened by 2 *leather chapes* sewed to the strap—4 *tugs for hip straps*, double, $1\frac{1}{4}$ inch wide, 6 inches long; two of them are attached to the buckles of the breech strap and two to the loops—4 *buckles* and 12 *loops* for do.—4 *safes* stitched under the buckles.

The *hip strap*, cut in one piece, 48 inches long and $2\frac{1}{2}$ inches wide, except in the middle, where it passes through the crupper and is $1\frac{3}{4}$ inch wide; each end is split into 2 *straps* 20 inches long, $1\frac{1}{4}$ inch wide, which buckle into the tugs on the breech strap.

The *breast strap*, $1\frac{3}{4}$ inch wide, 12 feet 6 inches long: it is made of three layers united by three seams, the middle one running zig-zag between the tongue holes; they are laid in such a manner as to make the strap 0.625 inch thick in the middle where the loop for the pole chain plays, tapering to $\frac{1}{2}$ inch thick at the ends which enter the buckles of the breech strap: it is supported by the links on the hames and by the side pipes through which it passes.

1 *sliding loop*, (iron covered with leather,) placed on the breast strap between the links on the hames.

1 *pole chain hook*, similar to the trace hook, welded into the sliding loop, the point turned towards the horse's breast; it receives the end of the pole chain and thus forms a direct connection between the pole and the breeching, independent of the collar and hames.

DIMENSIONS OF THE PRINCIPAL LEATHER PARTS OF THE HARNESS.

NAMES OF PARTS.				Width.	LENGTH.	
					Cut.	Finished.
				Inches.	Inches.	Inches.
HALTER.	crown piece	-	-	$1\frac{1}{4}$	30	30
	cheek strap	-	-	$1\frac{1}{4}$	$12\frac{1}{2}$	8
	brow band	-	-	$1\frac{1}{4}$	22	16
	nose band	-	-	$1\frac{1}{4}$	$18\frac{1}{2}$	13
	chin strap	-	-	$1\frac{1}{4}$	12	$5\frac{1}{4}$
	throat strap	-	-	$1\frac{1}{4}$	13	$6\frac{1}{4}$
	hitching strap	-	-	$1\frac{1}{4}$	84	84
	billet for do.	-	-	$1\frac{1}{4}$	9	9
	throat lash	-	-	1	44	42
	crown piece	} in one piece, {	-	$1\frac{3}{4}$	44	30
BRIDLE.	throat lash		-	$\frac{3}{4}$	42	42
	brow band	-	-	1	23	16
	cheek strap	-	-	1	$12\frac{1}{2}$	8
	billets for bits	-	-	1	$11\frac{1}{2}$	$9\frac{1}{2}$
	long rein	-	-	1	60	60
	short rein	-	-	1	42	40
	billets for reins	-	-	1	9	9
	coupling strap	-	-	1	84	84
	billet for do.	-	-	1	9	9
	skirts	-	-	$15\frac{1}{4}$	$24\frac{1}{2}$	$24\frac{1}{2}$
DRIVER'S SADDLE.	billet for collar strap	-	-	$1\frac{1}{4}$	10	8
	billets for girth and side pipe	-	-	$1\frac{1}{4}$	17	15
	stirrup leathers	-	-	$1\frac{1}{2}$	64	56
	girth	-	-	$2\frac{1}{2}$	45	45
VALISE SADDLE.	skirt	-	-	10	15	15
	girth billet	-	-	$2\frac{1}{2}$	26	23
	girth	-	-	$2\frac{1}{2}$	42	39
	billets for pipe straps	-	-	$1\frac{1}{4}$	18	18
HAMES.	crupper strap	-	-	$1\frac{1}{4}$	11	5
	valise strap	-	-	1	33	30
	trace tug	-	-	$1\frac{3}{4}$	17	7
	trussing strap	-	-	1	36	33
SIDE PIPES.	hames strap	-	-	1	21	18
	collar strap	-	-	$1\frac{1}{4}$	20	14
	pipe	-	-	9	27	27
	cuffs	-	-	$2\frac{1}{2}$	9	9
	billet for belly band	-	-	$1\frac{1}{4}$	17	$14\frac{1}{2}$
	belly band	-	-	$1\frac{1}{4}$	36	31
	tugs for pipe straps	-	-	$1\frac{1}{4}$	16	$7\frac{1}{2}$
	loin straps	-	-	$1\frac{1}{4}$	44	44
	layer for do.	-	-	$1\frac{1}{4}$	6	6

NAMES OF PARTS.				LENGTH.	
				Width.	
				In.	Ir. In.
CRUPPER.	dock	-	-	3½	14 14
	body	-	-	1¾	20 20
	layer for do.	-	-	1¼	10 10
	back strap	-	-	1¼	31 31
BREECHING.	breech strap	-	-	2½	48 42
	layer for do.	-	-	1¾	52 42
	tugs for hip straps	-	-	1¼	13 6
	hip strap	-	-	2½	48 48
	breast strap	-	-	1¾	3 layers. 150

Harness required for each horse.

PARTS.				Wheel Horses		Leaders.		Weight.
				Near horse.	Off horse.	Near horse.	Off horse.	
								lbs.
Halter	-	-	-	1	1	1	1	1¾
Curb bridle	-	-	-	1	-	1	-	3
Snaffle bridle	-	-	-	-	1	-	1	2½
Driver's saddle	-	-	-	1	-	1	-	16½
Valise saddle	-	-	-	-	1	-	1	5½
Collar, pair of hames, pair of traces and side pipes, crupper	-	-	-	1	1	1	1	24
Breeching	-	-	-	1	1	-	-	8
Total weight, lbs.				53¾	41¼	45¼	33¼	

A whip to each driver.—A leg-guard to each set of harness for a carriage.

Preservation of Harness in Store.

The store houses should be well ventilated, not too dry, but free from dampness. The different articles should be arranged according to kind and class, separated or in bundles according to their nature, so placed as to touch each other and the walls as little as possible, having a free circulation of air about them—saddles on trestles or bars—collars hung on pins—hames, with their straps, and traces with chains and hooks, hung up; the traces hanging vertically.—side pipes and belly bands piled on the floor or on shelves—surcingles and

breast straps stretched on racks—*halters, bridles, reins, &c.*, hung up in bundles of five or ten—*hames straps, collar straps, &c.*, hung up in bundles of ten or twenty—*bits, curb chains, trace hooks*, in boxes.

All these articles should be examined and cleaned at least four times a year.

The leather articles are brushed and greased with *neats' foot oil*, as often as their condition requires: if they have a reddish hue, mix a little lamp black with the oil. First brush the leather carefully, then pass over it a sponge wet with luke warm water; grease it slightly on the hair side, applying the oil with a soft brush before the leather is quite dry. In general, new leather is not greased until it has been in store three years, unless it should be found to require it. Iron parts which are not japanned or tinned, or from which the coating is rubbed off, are greased with tallow.

Horness required for each horse

Horness	PARTS	West-Horness		East-Horness		Total weight
		Neat horse	OR horse	Neat horse	OR horse	
Breaching	1	1	1	1	1	4
and side pieces, crupper	1	1	1	1	1	4
Collar, pair of hames, pair of traces	1	1	1	1	1	4
Valise saddle	1	1	1	1	1	4
Driver's saddle	1	1	1	1	1	4
Snaffle bridle	1	1	1	1	1	4
Curt bridle	1	1	1	1	1	4
Halter	1	1	1	1	1	4
Total weight		4	4	4	4	16

A whip to each driver—A leg-guard to each set of harness for a carriage.

Presentation of Horness in Store

The store horness should be well ventilated, not too dry, but free from dampness. The different articles should be arranged according to kind and class, separated or in bundles according to their nature, so placed as to touch each other and the walls as little as possible, having a free circulation of air about them—saddles on trestles or bars—collars hung on pins—downs with their straps, and traces with chains and hooks, hung up; the harness hanging vertically—side pieces and belly bands piled on the floor or on shelves—troughs and

CHAPTER SIXTH.

SMALL ARMS.

NOMENCLATURE.

Musket.—Model of 1840.—Plate 11.

Muskets of this model have not yet been issued to the troops.

BARREL. 1st, reinforce (from the breech to the corner of the flats and ovals, 1.89 in. ;) 2d, reinforce (to the lower band, 8.8 in. ;) chase (to the top of the upper band, 28.66 in. ;) muzzle, bayonet stud, breech, flats and ovals, vent, bore, thread for breech screw.

BREECH SCREW. Plug with its thread ; tenon, shoulders, tang, tang screw hole, *notch for side screw, *chamfer.

TANG SCREW : with countersunk head.

BAYONET. *Blade :* point, face flute, back flutes, edges of back and blade, corners, elbow, neck.—*Socket :* muzzle end, bridge end, bridge, mortice, *shoulder for the clasp, *stop pin.—**Clasp :* body, studs, bridge, groove, stop, *clasp-screw.

LOCK. *Lock plate :* front and rear ends, middle, sides, bolsters, notch for the pan, chamfer, convex ; 4 holes, for the pivots of the main spring, battery spring and bridle, and for the arbor of the tumbler ; 9 screw holes ; 1 mortice for the sear spring stud—*Two side screws.*—*Pan :* magazine, face, margin, *fence, lining, groove, convex surface, bridle, holes for battery screw and pan screw—*Pan screw.*—*Battery :* face, seat, back, top of the seat, *seat-flute, eye, heel, toe, hole for battery screw—*Battery screw.*—*Battery spring :* blade (upper and lower branch and elbow,) eye, (foot, neck,) pivot, notches, chamfer, hole for the screw.—*Cock :* body, comb with its notch, lower jaw, throat, breast, back, shoulder, throat hole, tumbler hole, screw hole.—*Upper jaw :* margin, notch, screw hole.—*Flint screw :* stem, screw thread, shoulder, neck, head, slit, hole.—*Tumbler :* body, *friction shoulder, arbor, square, pivot, hook, half-cock notch, cock notch, screw hole—*Tumbler screw.*—*Bridle :* body, eye, pivot, three holes for the tumbler pivot, sear screw and bridle screw—*Bridle screw.*—*Sear :* body, eye, nose, tang, screw hole, *friction shoulder—*Sear screw.*—*Sear spring :* blade (upper and lower branch and elbow,) eye, stud, notch, chamfer, screw hole—

Sear spring screw.—*Main spring* : blade (upper and lower branch and elbow,) hook, pivot, eye, (rest and point,) chamfer, screw hole—*Main spring screw*.

In all the screws the parts are: the stem, the head, the slit, the thread.

MOUNTINGS. *Upper band* : body, pipe for the rod, back, upper and lower straps, creases, *sight*, groove, tang, hole for the band spring pivot.—*Upper band spring* : stem, wire, shoulder, pivot.—*Middle band* : body, stud, creases, hole for the swivel rivet.—*Middle band swivel* : wire, eye, holes in the eye, rivet.—*Middle band spring* : stem, wire, shoulder.—*Lower band* : body, tang, creases.—*Lower band spring* : same as middle band spring.—*Side plate* : body, eyes and holes for the side screws—*Guard*.—*Guard plate* : body, bolsters, *trigger stud, 2 holes for the guard bow, 2 for wood screws, 1 for tang screw, *1 for trigger screw.—*Guard bow* : body, pillars, stems with their *screw threads, swivel stud and hole, 2 *nuts* for stems—*Swivel and rivet*.—*Trigger* : blade, tang or finger piece, hole for the screw.—**Trigger screw*—*Two wood screws* for guard plate.—*Butt plate* : body, toe, heel, corners, tang, screw holes.—*Two wood screws* for butt plate.

RAMROD.—Stem, head, screw.—**Ramrod spring* : stem, eye, spoon.—**Pin* for rod spring—**Stop* for rod.

STOCK.—Butt, comb, handle, head, facings, 1st and 2d reinforce, chase, shoulders for the lower and middle bands; *grooves* for the barrel and ramrod; *beds* for the tang and tenon, lock, side plate, guard plate, nuts of the guard bow and trigger stud, butt plate, rod spring and band springs; *mortices* for the trigger and *rod stop; *holes* for the rod, the side screws, tang screw, guard screws, butt plate screws, band springs, and *pin for the rod spring.

IMPLEMENTS.—*Screw-driver*—*Wiper*—*Ball-screw*—*Spring-vice*.

Materials of which the parts are made.

Steel : Face of the battery, tumbler, sear, flint screw, lock springs, band springs, ramrod spring and its pin, ramrod, blade of the bayonet, screw-driver, wiper, and ball screw.

Brass : Pan and sight.

Wood : Stock (black walnut.)

Iron : Socket of the bayonet, back of the battery, and all the other parts not enumerated under the three preceding heads.

NOTE.—The brass for parts of small arms is composed of 80 copper, 17 zinc, and 3 tin.

Musket.—Model of 1822.

This is the model of the musket now in the hands of the troops and of nearly all those in store at the arsenals.

The parts are the same as those of the model of 1840, omitting such as are marked *, and adding a *trigger pin*. The other differences between the two models consist in variations in the form and dimensions of some of the parts; the material of the several parts is the same with the exception of the *tumbler*, *sear*, *flint screw*, and *band springs* which are of *iron* in the model of 1822.

There are some muskets remaining of models prior to that of 1822, some of which have *iron pans* forged with the lock plate.

Musketoön.—Model of 1840.—Plate 11.

This model is similar to that of the musket of 1840. The parts are the same, omitting the *bayonet* and the *middle band* and *band spring*, and observing that one swivel is on the lower band and the other near the butt of the stock, on a *plate* fastened by 2 *wood screws*; the lower band and the swivel plate have *studs* for attaching the swivels. The musketoön has a *bayonet stud* by means of which the musket bayonet (1840) may be used with it if occasion requires.

Pistol.—Model of 1836.—Plate 11.

The parts not described are similar to the corresponding parts in the musket of 1822 and the materials of the parts are the same in the two arms.

BARREL. *Sight*—*Swivel stud* with a hole for the swivel screw.

BREECH SCREW. *Guide*.

TANG SCREW.

LOCK. Same parts as musket lock; the pan has a *fence*.

MOUNTINGS. *Band*: branch with a hole for the forward side screw.—*Side plate*—*Guard plate*; 1 hole for guard screw—*Guard bow*, riveted to guard plate—*Guard screw*, (wood screw)—*Trigger*—*Trigger pin*—*Butt plate*; cap, strap, hole for screw—*Butt plate screw* (wood screw.)

RAMROD. Screw hole for head of wiper.

RAMROD SWIVEL. *Two side bars*, with 2 holes in each—*Cross bar*, hole for the ramrod—*Swivel screw*.

STOCK.

IMPLEMENTS. *Screw driver*—*Wiper*—*Ball screw*—*Spring vice*—*Bullet mould*.

Pistol.—Model of 1819.

Varies from that of 1836 chiefly in the following parts :

The *pan* has no *fence* :

There is a *cock bolt*, to hold the lock at half cock :

The *band* has no *branch* ; it is formed like the lower band of the musket, and is held by a *band spring*.

The *butt plate* has a short branch and is held by 2 *screws*.

The *tang of the breech screw* extends to the butt of the stock, taking the place of the *strap* of the butt plate in the model of 1836.

For differences in dimensions and weights, see TABLE, below.

Common Rifle.—Full stocked : 1819.

The nomenclature is the same as that of the musket of 1822, with the following variations :

BARREL. Add, *grooves* and *lands*, *guide* and *sight*.

MOUNTINGS. Add, *Box plate* ; lid, strap, hinge, 2 holes for strap screws—Two wood screws for strap—*Box plate spring* (steel,) upper branch, lower branch, and elbow—*Box catch spring* (steel) upper and lower branch and elbow, head with its notches, hole for screw—One wood screw for catch spring.

RAMROD. The head of brass.

STOCK. Add *box*, and *beds* for box plate spring and catch spring.

IMPLEMENTS. Add *bullet mould*.

HALL'S PATENT ARMS.

These arms load at the breech by means of a moveable chamber called the *Receiver*.

Hall's Rifle.

BARREL: Muzzle, butt (slightly concave,) squares, bore, *grooves and lands, counterbore and chamfer at the muzzle, 4 tapped holes for supporter screws ; sight and *bayonet stud—*Guide*, fitting in a dovetailed notch in the barrel.

TWO SUPPORTERS: Each with 2 countersunk holes for supporter screws, 3 holes for side screws, and 1 for chock screw—4 *supporter screws* ; the heads of the supporter screws are dressed smooth and flush with the outer face of the supporter which is permanently connected with the barrel by a *protector* dovetailed in the supporter and soldered in place—2 *chocks*—2 *chock screws*.

RECEIVER AND LOCK: Muzzle (convex,) shoulders, butt, bore, chamber, vent ; upper, lower, right and left sides—On upper side: **pan* (fence, toe ;)

**battery seat* ; *mortices* for battery and cock ; *holes* for *battery screw, sear spring and sear spring screw.—On right and left sides : *slot* for side screw (receiver axis ;) *holes* for cock screw and sear screw.—On lower side : *stud*, with a slit and hole for catch screw, and mortice for main spring ; *bed* for main spring ; *tapped holes* for main spring screw and catch spring screw.

3 *side screws*—**battery screw*—**battery spring*—**battery spring screw*—*cock*, notches for cock and half cock—*cock screw*—**upper jaw*—**flint screw*—*sear and trigger*—*sear screw*—*sear spring*—*sear spring screw*—*set screw*—*main spring*—*main spring screw*—*link*—*link screw*.

BUTT PIECE, (behind the receiver :) Holes for butt piece screw and side screw—*butt piece screw*.

STOP : Dovetailed into the under side of the butt of the barrel, to hold up the receiver.

APRON : Lining the stock at the junction of the barrel and receiver—*apron screw*.

CATCH : *Tang, notch, body, shoulders, tenon, hole for catch screw—*catch screw*—*catch spring*—*catch spring screw*.

MOUNTINGS : *Upper band*—*upper band spring*—**middle band*—**swivel and rivet*—**middle band spring*—*lower band*—**lower band spring*—*catch plate* : holes for apron screw and catch plate screw—*catch plate screw*—*guard plate* : mortice for trigger, holes for guard plate screws, butt piece screw and pillars of guard bow—2 *guard plate screws* (wood screws)—*guard bow*—**swivel and rivet*—*butt plate*—2 *butt plate screws* (wood screws.)

*BAYONET.

RAMROD.

STOCK.

IMPLEMENTS. *Screw driver*—*Wiper*—*Spring vice*—*Bullet mould*.

The materials of which the parts are composed are the same as those used for similar parts of the musket of 1822, except the *sight* and the *pan* which are made of iron.

Hall's Carbine.—Model of 1840.—Pl. 11.

This arm has a *percussion lock*. It is smooth bored and of rifle calibre.

The parts are similar to those of the rifle, with the following exceptions :

Omit those parts of which the names are marked * in the nomenclature of the rifle.

BARREL: Add *stud* for the rammer head.

STOP: Attached to the apron, instead of to the barrel.

RECEIVER AND LOCK: Add *nipple*: cone, square, shoulder, screw thread, vent. The head of the *cock* is countersunk to receive the cone.

MOUNTINGS: The *catch plate* and the *guard plate* are in one piece, with a mortice for the catch. Add *lever*, for opening the receiver, which is attached by *studs* and a *rivet* to the guard plate—*swivel bar and ring*, held by two of the side screws and attached to the lower band by a *stud and screw—rod spring and pin*.

NOTE.—Arrangements are in progress for adapting *percussion locks* to all small arms, agreeably to a decision of the War Department, made in February 1841.

PRINCIPAL DIMENSIONS AND WEIGHTS OF SMALL ARMS.

DIMENSIONS.		Musket.		Musk- etoon.	Rifle.	Pistol.	
		1822.	1840.	1840.	1819.	1819.	1836.
		In.	In.	In.	In.	In.	In.
BARREL.	True diameter of the bore - - -	0.69	0.69	0.69	0.54	0.54	0.54
	Variation allowed, <i>more</i> - - -	0.015	0.015	0.015	0.015	0.015	0.015
	Diameter at the muzzle - - -	0.82	0.85	0.84	0.86	0.81	0.22
	Diameter at the breech, between the flats - - -	1.25	1.25	1.22	1.15	1.00	1.0
	Length, with the breech screw out -	42.00	42.00	26.00	36.00	10.10	8.5
BAYONET.	Length measured from top of socket-	16.00	18.00	-	-	-	-
RAMROD.	Length - - -	41.96	41.70	25.7	36.00	10.25	8.8
ARM complete.	{ Length, from butt to muzzle -	57.64	57.8	41.0	51.31	15.72	14.4
	{ Length, with bayonet fixed -	73.64	75.8	-	-	-	-
WEIGHTS.		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
BARREL, without breech screw - - -		4	4 3	2 14	5 3 $\frac{1}{4}$	1 1 $\frac{1}{2}$	1 0 $\frac{1}{4}$
LOCK, with side screws - - -		1 3 $\frac{3}{4}$	1 3 $\frac{1}{2}$	12 $\frac{1}{4}$	12 $\frac{3}{8}$	7 $\frac{1}{2}$	8 $\frac{3}{4}$
BAYONET - - -		11 $\frac{3}{4}$	10 $\frac{3}{8}$	-	-	-	-
STOCK - - -		2 1	2	-	-	-	-
ARM complete,	{ without bayonet - - -	9 5 $\frac{1}{2}$	9 12 $\frac{1}{2}$	7	9 3 $\frac{1}{4}$	2 10 $\frac{3}{4}$	2 9 $\frac{1}{2}$
	{ with bayonet and flint - -	10 1 $\frac{1}{4}$	10 8	-	-	-	-

HALL'S PATENT ARMS.

DIMENSIONS.						Rifle.	Carbine.
						In.	In.
BARREL.	{	Diameter of bore	-	-	-	0.52	0.52
		Variation allowed, <i>more</i>	-	-	-	0.008	0.008
		Depth of grooves	-	-	-	0.01	-
		Diameter at the muzzle	-	-	-	0.785	0.75
		Diameter at the breech	-	-	-	1.07	1.1
		Length	-	-	-	32.7	21.
RECEIVER.	{	Exterior diameter	-	-	-	1.	1.
		Diameter of bore	-	-	-	0.545	0.56
		Diameter of chamber	-	-	-	0.4	0.46
		Depth of bore	-	-	-	1.1	1.4
		Depth of chamber,	-	-	-	1.3	0.98
BAYONET.		Length of blade	-	-	-	16.5	
RAMROD.		Length	-	-	-	32.0	19.5
ARM complete.	{	Length from butt to muzzle	-	-	-	52.5	40
		Length with bayonet fixed	-	-	-	68.5	
WEIGHTS.						lbs. oz.	lbs.
BARREL, with supporters						4 13	3
ARM complete,	{	without bayonet	-	-	-	10 4	7
		with bayonet	-	-	-	10 15	

INSPECTION OF SMALL ARMS.

All the materials used in the manufacture of arms must be of the best quality, and they should be tested by the inspectors, according to the methods indicated in *Chapter 12*.

The wood for gun stocks should be seasoned at least 3 years and kept in a dry place 2 years before being worked; it must be free from knots and sap, and no wood which is *brash* or light (cut from old trees,) or worm eaten, or in any degree decayed, or which is cut across the grain at the handle of the stock, or which is kiln dried, should be used or received.

The following rules for inspection apply more particularly to the musket of the model of 1840, when not otherwise stated, but the principles and most of the details of the inspection are the same for all fire arms, whether made at the national armories, or by contract at private establishments.

The attention of the inspecting officers should be directed, as much as possible, to the operations of the workmen in the course of the fabrication of arms.

Each component part is first inspected by itself and afterwards the arm in a finished state.

The materials and the forms and dimensions of all the parts must conform strictly to those of the established patterns; the workmanship and finish must be equal to those of the model arms, and the several parts must be browned, blued, case hardened, or polished as in the standard model.

The forms and dimensions of the parts are verified by means of the following gauges:

List of Verifying Gauges for the Musket of the model of 1840.

Each set of gauges is distinguished by the letter with which it is marked. The pieces of the same set are numbered as in the following list.—In some cases *each groove* of a gauge is numbered; for instance those of the barrel, rod, and bayonet gauges: these numbers will not be found on the list.

No.	For Barrels.
1	1 Stock gauge for the length of the barrel and rod, with sections for applying the grooves of the gauge.
2	1 Groove gauge for the diameters of the barrel.
3	2 Plugs, standard and limit, for the calibre of the barrel.
3 (bis)	1 Taper plug.
4	1 Tap and size die for the barrel and breech screw.
5	1 Receiving gauge for the barrel and breech screw.
6	1 Groove gauge for adjusting do.
7	1 Gauge for the vent.
8	1 Receiving gauge for the muzzle.
9	1 Charger for 1-18th of a pound of powder.
10	1 Charger for 1-22nd of a pound of powder.
	For Locks.
11	3 Patterns for lock plates.
12	1 Groove gauge and pattern for lock plate.
13	1 Groove and receiving gauge for pans.
14	1 Pan square and pattern for pan lining and fence, &c.
15	1 Groove gauge for batteries.
16	1 Receiving gauge for batteries.
17	1 Receiving and groove gauge for tumblers.
18	1 Receiving and groove gauge for bridles.
19	1 Receiving and groove gauge for sears.
20	1 Receiving gauge for cocks.
21	1 Groove gauge for cocks.
22	1 Pattern with size drift for cocks.
23	1 Receiving and groove gauge for jaws.
24	1 Groove gauge, &c., for lock springs.
25	1 Grooved and tapped gauge for flint, tumbler, small lock, bayonet, clasp and trigger screws.

- 26 1 Receiving gauge for finished locks.
 27 1 Flint screw wrench, and gauge for depth of screw hole in the tumbler.

For Mountings.

- 28 1 Pattern for butt plates.
 29 1 Receiving gauge for butt plates.
 30 1 Groove gauge for bands.
 31 1 Gauge mandril for lower bands.
 32 1 Gauge mandril for middle bands.
 33 1 Gauge mandril for upper bands.
 34 1 Groove and receiving gauge for guard plate bow and nuts.
 35 1 Pivot groove and tap gauge for trigger mortice, screw hole, &c., in the guard plate.
 36 1 Pattern and groove gauge for guard bows.
 37 1 Receiving gauge for guards.
 38 1 Receiving and groove gauge for triggers.
 39 1 Receiving and groove gauge for lower and middle band springs.
 40 1 Receiving and groove gauge for upper band springs.
 41 1 Receiving and groove gauge for side plates.
 42 1 Receiving and groove gauge for rod springs and wire pins.
 43 1 Groove and plug gauge for swivels.
 44 1 Grooved and tapped gauge for side and tang screws.
 45 1 Groove gauge for breech plate and guard screw.
 46 1 Receiving gauge for bayonets.
 47 1 Scabbard gauge for bayonets.
 48 1 Groove gauge for bayonets.
 49 1 Plug for bayonet sockets.
 50 1 Groove and plug for bayonets and socket clasps.
 51 1 Grooved and tapped gauge for rods.
 52 1 Groove gauge and pattern for rod stop.
 53 1 Apparatus for weighing lock springs; consisting of a stock, scale-beam and brass pods weighing 10 pounds.
 54 1 Brass gauge for the angle of the stock, divisions for the bands and the distance of the upper band from the end of the muzzle of the barrel.
 64 1 Gauge screw plate, tapped for all the sizes of the screws in the musket except the breech screw.

Appendages.

- 55 2 Hand screw drivers for locks.
 56 2 Hand screw drivers for guard bow nuts and trigger screws.
 57 1 Hand screw driver for side screws.
 58 1 Iron brace with screw drivers.
 59 1 Bench hammer.
 60 1 Punch for wire pins.
 61 1 Punching wire.
 62 1 Pair of small steel callipers.
 63 1 Steel square divided into inches and decimals of an inch.

Inspection of barrels.

The first inspection of the barrel is made after it is reduced to the dimensions required for proof, which are verified by the proper gauges for that purpose: these dimensions are nearly the same as those of the finished barrel (not more than 0.003 in. greater in the exterior diameter, and 0.003 in. less in the diameter of the bore,) leaving only sufficient surplus metal (about 1½ oz. in a musket barrel) to enable the workman to dress the barrel in fine boring and to remove the marks made in straightening the barrel after proof. The thread for the breech screw in the barrel must be cut and the bayonet stud brazed on. The inspector will see that the exterior and interior dimensions of the barrel are correct; that there are no interior hammer marks, ring bores, cinder holes, flaws, cracks or other defects, which will not disappear in the finishing, and that the thread of the breech screw is accurately cut.

The barrels rejected for defects that cannot be remedied will be stamped on the upper side, in a line with the vent, with the mark of condemnation, which will be in all cases the letter *C*. If the defect is of such a nature as not to prevent the use of the barrel when cut off, the mark may be made on the defective part.

Proof. The barrels which pass this inspection will then be proved by being fired twice, with the following charges:

KIND OF BARREL.	1ST CHARGE.			2D CHARGE.			SIZE OF BALL.		SIZE OF WAD.
	Powder.	Balls.	Wads.	Powder.	Balls.	Wads.	Weight.	Diam.	Square.
	lbs.	No.	No.	lbs.	No.	No.	lbs.	In.	In.
Musket - - -	1-18th	1	2	1-22nd	1	2	1-15th	0.676	4
Musketoön - -	1-22nd	1	2	1-28th	1	2	1-15th	0.676	4
Hall's carbine -	1-28th	2	2	1-32nd	1	2	1-32nd	0.525	3.25
Hall's rifle - -	1-28th	2	2	1-32nd	1	2	1-32nd	0.525	3.25
Common rifle -	1-28th	2	2	1-32nd	1	2	1-32nd	0.525	3.25
Pistol - - -	1-32nd	1	2	1-40th	1	2	1-32nd	0.525	3.25

One wad is placed on the powder and the other on the ball, (the upper ball when there are two,) and the charge is well rammed with copper rods. The wad occupies, when rammed, about $\frac{3}{4}$ in. in the length of the barrel.

The barrels are closed for proof either with their breech screws, (in which case the vent must be drilled before proof,) or with *proving plugs* having vents in them.

The barrels of Hall's arms, being without threads for breech screws, are closed with smooth proving plugs 0.7 in. long, fitting tight to the barrel: the plug is held in its place by a wedge bearing against a stirrup attached to a collar which

rests against the shoulder of the barrel; these barrels are proved before the supporters are attached to them; they are loaded at the muzzle like other barrels.

Rifle barrels are proved before being rifled.

Musket powder will be used for proving the barrels of muskets and musket-oons, rifle powder for all the others; the powder must be of the best quality, giving a range of not less than 250 yards by the mortar eprouvette; it must be proved immediately before being used, unless it shall have been proved within one year and the inspector have no reason to suppose that it has become deteriorated.

The measures for the proof charges should be of a conical form with the mouth as small as may be convenient, in order that there may be less variation in the quantity of powder; their dimensions will be determined by the rules in *Chapter 9*.

Before commencing the proof of barrels, the inspector will satisfy himself as to the quality and proof of the powder, the size of the balls and of the wads.

The inspector will observe the greatest caution in having the barrels properly loaded; for which purpose, after they are placed on the proving bed, he will pass a ramrod into each, to verify the accuracy of the charge.

After the discharge he will again pass the ramrod into each barrel, and those which have missed fire will be pricked and primed and discharged, before proceeding to the second proof charge.

After the second proof charge, the inspector will examine the barrels which have burst and note the cause of defect, whether in the materials or workmanship.

He will then examine those which have not burst and he will mark, as condemned, any which are evidently defective; the others will receive the proof stamp, viz: the initials of the inspector's name with the letter *P* under them, placed on the left side of the barrel, just above the left flat, and about 1 in. from the breech. The barrels will be immediately washed clean in hot water and dried, after which they will be again carefully examined.

They will now be inspected in the interior and on the exterior, the inspector will reject such as are too large in the bore and such as have holes, cross cracks, scales, seams or ring bores—he will examine the brazing of the bayonet stud and see that the barrel is not notched too deep or indented inside.

The barrels having been reduced to their ultimate dimensions, straightened and completely finished, are again strictly inspected to verify the straightness of the bore, the exterior and interior diameters, their weight, (which should not vary more than 1 oz. from the standard weight of 4 lb. 3 oz.,) the tap for the breech screw, the size, position and direction of the vent.

The straightness of the barrel may be ascertained by holding it up to the light and throwing the shadow of a straight edge on the different parts of the bore, by which means an experienced eye readily detects any inaccuracy in the bore. The small or *standard* plug should pass freely through the whole length of the barrel including the threads for the breech screw, and the bore should not admit the large or *limit* plug.

The *grooves of rifle barrels* should be carefully examined to see that they are formed according to the pattern and that they are even and uniform throughout.

The *breech screws* will be examined to see that they are of the proper dimensions, are sound in every part, and have good threads; those of the model of 1840 are not case hardened; the screw must be tried in the barrel, to see that it occupies all the threads in the tap of the barrel and that it is not loose after entering three threads.

The *vent* should enter the bore of the barrel close to the end of the breech screw without being obstructed by it.

The breech screw having been screwed up and the vent stopped, the barrel is then filled with water and left standing about six hours, when it is again examined and if no water has passed through the breech or made its appearance on the exterior in any part, the barrel is approved.

Marks. Barrels condemned for defects detected after proof or at any time in the course of inspection are marked with the letter *C*, struck in deeply; those finally received are stamped in addition to the proof mark, with the letters *U. S.*, on the top of the barrel 1 in. from the breech, and the *Year* of fabrication underneath those letters, in the direction of the axis of the barrel, ending at the breech.

Report of Inspection of Barrels.

After the inspection of each lot of barrels the inspector will make a statement, showing:

1. The number of barrels offered for proof.
2. The number rejected before proof.
3. The number burst in proof.
4. The number rejected after proof, for flaws, cross cracks, or other defects.
5. The number received after the proof and inspections.
6. The number rejected on inspection of the finished arm.

These statements furnish the materials for the reports of inspection required by the Ordnance Regulations.

Locks.

Examine all the limbs to see that they are sound, well filed and of the proper form; try the temper of the hardened parts with a fine cut file.

Batteries. To ascertain that the steel is of good quality and of sufficient thickness on the face of the battery, the inspector is authorized to have four in each hundred case hardened and broken.

Tumblers must be verified separately with great care.

Springs. The relative proportion in the strength of the springs is determined by snapping the lock in the hand, as a lock that will uncover the pan when snapped in the hand will always do so when snapped on the gun, unless it be wood bound; though the reverse is not always true.

The relative strength of the lock springs as indicated by the weights they will bear is nearly as follows:

Main spring	-	-	-	80 lbs.
Battery spring	-	-	-	60 "
Sear spring	-	-	-	20 "

Screws. Examine the forms of the stems and heads of all screws and the cutting of the threads, and gauge them.

Pans. The brass should be perfectly free from holes and flaws; the quality of the composition may be judged of by breaking some of those rejected for defects and by comparing the fracture with that of standard bars, or of brass pieces of good quality.

Lock plates. Verify with the proper gauges the form and dimensions, the accuracy of the position of the holes and the threads of those which are tapped; see that the plate is sound and free from cracks and flaws, especially about the tumbler hole.

Finished locks. The locks having been put together, see:

1st. That they are clean in the inside;

2d. That the sear works freely when the sear screw is driven as far as it will go, and that the nose is sufficiently strong and falls properly into the notches of the tumbler.

3d. That the bridge has no cracks or flaws about the holes for the tumbler-pivot and screws.

4th. That the springs are well bent and of good proportions; that the fixed branches fit close to the lock plate, and that the moveable branches swing clear of it without having too much play.

5th. That the slits of the screw heads are not defective.

6th. That the arbor and pivot of the tumbler fit accurately in their holes.

7th. That the hook of the tumbler does not fall below the edge of the lock plate when the cock is down.

8th. That the notches of the tumbler are sound and smooth, and that the tumbler fits and turns well.

9th. That the cock fits well on the square of the tumbler, that it does not rest on the lock plate when screwed up tight, and that it has the proper set in relation to the battery.

10th. That all the parts work well together.

Marks. The place and year of fabrication are marked on the face of the lock plate, in rear of the cock; at the national armories an *eagle* and the letters *U. S.* are stamped on the lock plate, under the pan; at private armories, the letters *U. S.* with the name of the contractor.

Locks approved on inspection are marked on the underside of the pan with the initials of the inspector's name.

Mountings.

The forms and dimensions are verified with the appropriate gauges and patterns. The rod springs should not be so stiff as to endanger splitting the stock. The trigger should be well fitted to the guard plate, with as little lateral play as is consistent with its free movement. The form, size and threads of the screws should be carefully examined. The letters *U. S.* are marked on the tang of the butt plate.

Ramrods.

The ramrods of the model of 1840 are of steel throughout. The temper of the rod is tested by springing it in four directions with the point resting on the floor. The musket ramrod should bend 6 inches from a right line joining the ends; the rod should spring back perfectly straight without setting. Its soundness and freedom from flaws and cross cracks are ascertained by the sound it gives when suspended by one end and gently struck with a piece of metal, and by passing it over the edge of a block of wood or the closed jaws of a vice, pressing down the ends at the same time and turning the rod so as to present every side successively to inspection. Rifle and pistol rods are subjected to the last tests only. The diameter of the rod and the tap of the screw for the wiper are verified with the proper gauges. The length is also verified.

Marks. The rods approved are marked with a small stamp near the head.

Bayonets.

The form and dimensions of the bayonet are verified with the proper gauges, and the temper is proved as follows:

Two iron staples are fixed in a piece of oak plank on a work bench, $16\frac{1}{2}$

inches apart; one of them serves as a bridge and has notches to receive the blade, the other serves as a staple for holding the point of the bayonet close to the plank: the bayonet is fixed on a barrel to the butt of which is fastened a brass ball weighing about 6 lbs., so that by inserting the point of the blade in the staples, the face and back resting alternately on the bridge, the blade sustains a weight of about 9 lbs., which springs it about $\frac{5}{8}$ of an inch. In this situation the blade is also examined to detect flaws and cross cracks. It should not remain bent after this trial.

The inspector then seizes the blade near the point and strikes the elbow smartly on the work bench, to ascertain that the welding is sound.

If the proof shows no defects, he verifies the dimensions and bore of the socket and the accuracy of the channels. He examines the dimensions of the clasp, to see that it fits well to the shoulder, that it turns evenly without binding in any part, that the stop is well placed and firmly set, that the clasp screw and its thread in the stud of the clasp are well cut, that the elbow has the proper form and dimensions.

Marks. Bayonets are marked on the face of the blade, near the neck, with the letters *U. S.*; those approved are marked on the neck with the inspector's stamp; those rejected for defects that cannot be remedied are marked with the stamp of condemnation.

Stocks.

The examination of the stock will be directed:

1st. To the quality of the wood; that it has good straight grain, is well seasoned and free from sap and worm holes.

The degree of seasoning is indicated by the smell of the wood at a fresh cut place—by the appearance of the lock and barrel, &c., when removed from the stock; they will be rusted by unseasoned wood—by rolling a thin shaving between the fingers; it will crumble if the wood be well seasoned, otherwise it will be tough and will bend.

The medium weight of a well seasoned musket stock of the model of 1840 is 2 lbs: a stock made of good walnut will not weigh less than 1 lb. 13 oz.

2d. To the workmanship; that it is free from splits especially about the barrel groove and heading; that it has not been split and glued up; that the grooves and beds are of the proper forms and dimensions, that the roundings for the bands are smooth and accurate, that the handle and comb are of the proper size and form, and that the stock has the proper *fall* or crook and is of the right length; that the holes are well drilled and that those for the wood screws have good threads.

In examining the bed of the lock, see :

- 1st. That all the edges are sharp and smooth.
- 2d. That the beds of the sear screw and sear spring screw are not bored down to the trigger or to the breech screw.
- 3d. That the bed of the main spring and main spring screw do not penetrate to the barrel.
- 4th. That the hole for the tang of the sear is as small as possible and does not extend more than 0.04 in. beyond the trigger mortice.
- 5th. That the wires fit well in their holes and that the trigger wire (of the model of 1822,) is not too near the hole for the tang of the sear.

Marks. The stocks inspected are marked on the left side with the stamp of approval, (the initials of the inspector's name,) or of condemnation, as the case may be.

Appendages.

Ball screws and wipers are examined by screwing them on a piece of ramrod furnished with a handle, to verify the accuracy of the screw thread ; the temper of the branches is tested by pressing the points on a piece of hard wood, in which proof they should spring back to their proper form.

Screw drivers, by inserting the blade in a vice, or in a slit made for the purpose, and twisting the handle by means of a rod placed between the two parts of the bent end.

Other implements are examined by applying the appropriate patterns &c., and their soundness may be further tested by striking them a smart blow with a hammer.

Finished arms.

Finished arms offered for inspection must be taken entirely to pieces, and each part must be examined as above directed ; if the parts have been previously inspected, see that they have suffered no subsequent injury. This being done, the arms will be put together and examined in their complete state. Some of the arms in every lot should be put together by the inspector himself.

The inspector will examine the finished arms on every side, to see that the parts are well fitted together—he will verify the principal dimensions and forms by means of the appropriate gauges and patterns.

The diameter of the bore must be verified with the standard and limit gauges. The barrel should enter the groove of the stock to the depth of half its diameter and should bear well in the whole length of the groove, particularly at the breech. The vent should be quite round, and accurate in its dimensions, position and direction, and a wire should be passed into it to see that it is free. The shoulders of the breech screw should fit close to the end of the barrel and it must

be free from cracks or flaws about the tang screw hole; the tang screw should be perpendicular to the tang. The bore of the barrel should be clean and bright.

The temper and the screw of the ramrod are tried as before directed, also by dropping it into the barrel which will test its soundness and length; the fitting of the groove is ascertained by drawing and returning the rod smartly several times, to see that it holds well and does not stick too fast—the pistol and carbine ramrods should hold more firmly than that of the musket—the ramrod must bear on the rod stop, and in that position its head should not project beyond the end of the barrel; it should fill the groove well; the open part of the groove should be in the centre of the stock, the covered part in the middle of the thickness of the stock between the outside and the bottom of the barrel groove, and the rod should not interfere with the front side screw.

By sighting along the barrel it will be seen whether it is well stocked, whether the upper band is well placed and the sight central.

The socket of the bayonet should be even with the muzzle of the barrel at the upper end and should clear the upper band about 0.05 in. Work the clasp to see that the ramrod does not interfere with it, that it bears well on the shoulders, that the clasp screw holds well, that the stop is firmly fixed, and that the clasp moves evenly without binding; the blade of the bayonet should set outwards a little towards the point. To try the strength and temper of the bayonet when fixed: spring it smartly in four directions, towards the back and face and each edge, resting the point on the floor and grasping the butt of the stock with the right hand and the middle of the barrel with the left. Examine the fitting of the bayonet to the barrel and see that the inside of the socket is clean and free from rust, and that the bayonet stud is well brazed and of the right dimensions.

Examine carefully the action of the lock; see that the flint and flint cap are of the proper dimensions; snap the lock to see if the battery uncovers the pan and if it throws sufficient fire into the pan. If the battery does not uncover the pan, the main spring is too weak or the battery spring too strong; if it uncovers and springs back, the reverse is the case: the proper proportion in the strength of the springs should be established. Let the cock down several times, to judge of the working of the lock.

See also: 1st, that the interior parts are not wood bound.

2d. That the cock stands off (0.02 in.) from the lock plate.

3d. That it does not go off at half cock, when the trigger is pulled hard.

4th. That it goes neither too hard nor too easily when cocked.

5th. That it does not stop at half cock.

6th. That the trigger is steady at cock and half cock, and free when the cock is down.

7th. That the fixed branch of the battery spring fits close to the lock plate and that the moveable branch does not rest on it.

8th. That the cock has sufficient sweep; the axis of the flint screw and the chord of the face of the battery should be nearly parallel to each other when the lock is at half cock.

9th. That the cock falls evenly, without a jerk.

Examine the soundness of the cock at the tumbler hole and throat hole; see if the hole in the flint screw is above the crest of the cock when the screw is turned in as far as it will go: see that the battery moves without friction on the barrel; that it is not too stiff when the battery screw is turned in hard; that it covers the pan well and fits close to the flat of the barrel; that the pan is sound and free from cracks about the hole for the battery screw. The front side screw should be clear of the battery spring, so as not to press it off. The vent should be over the middle of the pan and a little above its margin.

In examining a finished lock by itself observe the rules laid down above, see that the lock plate fits accurately in its bed and that the wood around it is full and sound.

The front part of the trigger at half cock should be nearly perpendicular to the surface of the guard plate; the slit for the trigger should be of the exact width, so that the trigger shall have no lateral motion.

It is important that, in the model of 1840, the guard plate should bear firmly on the wood in every part; as otherwise, by driving the tang screw too hard, the trigger might be brought too close to the sear and the action of the lock be thus interfered with.

The butt plate should be well fitted in the centre of the stock.

The bands should fit smoothly at the shoulders and closely to the stock and barrel, but not so tight as to require a great effort to remove them. The band springs should not be too deeply set; they should spring back freely when pressed down; the holes for the wires should not interfere with the barrel or ramrod grooves.

All the mountings should fit smoothly to the stock. The stock should have the proper fall or crook, which is ascertained by applying the pattern and by trying the piece in the position of aiming.

See also below: *Inspection of arms in service.*

SPECIAL INSTRUCTIONS FOR THE INSPECTION OF HALL'S PATENT ARMS.

The foregoing rules for inspection of arms are to be observed here as far as they are applicable; such as those relating to the quality of materials and

workmanship; the proving of barrels, bayonets and ramrods; gauging the parts and ascertaining that they are sound; that their forms and dimensions agree in all respects with those of the standard models, and that they are not inferior in finish to those models.

The following instructions apply exclusively to arms of Hall's patent.

These arms should be fabricated in such a manner that the component parts of all the arms of the same kind shall interchange, or fit equally well together. In order to test the accuracy of the work in this respect, examine and gauge the various component parts belonging to any number of arms offered for inspection and cause the arms to be put together by taking the parts promiscuously from the whole number examined. Take then a certain proportion of the finished arms (say 10 in every hundred of the first 400 arms, after that about 10 in 400,) and interchange the component parts of each of these lots of 10, as follows:

1st. Apply all the bayonets to one and the same rifle ascertaining that each fits well, resting on the end of the stock, and that the groove does not touch the sight at its upper end, but is about 0.06 inch distant from it when the bayonet is in its place on the rifle.

2d. Apply each receiver to one and the same arm—ascertain that the joint between its muzzle and the breech of the barrel is a little open, (from 0.004 in. to 0.008 in.) so as to admit of one thickness of common writing paper without jamming it, and two thicknesses of the same, jamming and holding them tight. Also, ascertain that its catch fits well to the catch plate below, and that when the receiver is pressed hard down, the space between the catch notch and the catch plate is not less than 0.008 in. nor more than 0.016 in.—that the receiver admits of a little motion, or has between it and the chock on each side of it a play of not less than 0.004 in. nor more than 0.008 in.

Ascertain that the opening on each side between the receivers and the supporters, in rear of the chocks, is not less than 0.008 in., nor more than 0.016 in.

That the opening between the rear end of the receiver and the butt-piece, and between the front part of the shoulders (before the chocks) and the supporters, is not less than 0.016 in. nor more than 0.03 in. That the receiver opens and shuts with ease and that the trigger which is attached to it passes through the guard freely and clear of the end of the mortice in the guard, both in front and rear, and that when the piece is cocked and the receiver shut, the trigger stands $\frac{1}{8}$ of an inch from the guard behind.

3d. Apply one catch plate to all the stocks; put in a receiver and ascertain that it fits the catch: also, apply all the catch plates to one and the same stock and receiver, ascertaining that each one fits.

4th. Apply all the catches to each receiver and ascertain that the catch fits on the plate below; that the opening between the hook of the catch and the catch plate is correct as before stated.

5th. Apply all the chocks to one and the same arm and ascertain that the opening or joint formed between the receiver and the barrel is within the limits before prescribed. Apply one and the same pair of chocks to each arm, and ascertain that the opening in the joint between the receiver and the barrel is the same as before.

6th. Apply all the butt pieces to one and the same arm ascertaining that each one fits alike and corresponds well with the ends of the supporters, with the wood of the stock and with the screw holes through the stock and the supporters—then apply one and the same butt piece to all the arms and ascertain the same points as before.

7th. Apply all the butt plates to one and the same stock, but without turning in the screws except in a few of the plates, otherwise the hold of the screw in the wood will be injured; but ascertain that the holes in the plate correspond with those in the stocks at the same time that its outer edges correspond with the outside of the stock—then apply one and the same butt plate to all the stocks and ascertain that it fits alike to each, turning in the screws in this latter case.

8th. Apply all the guards to one and the same stock, ascertaining that each fits the wood well around its edges and at the holes—then apply one and the same guard to each of the stocks, ascertaining that it fits as before.

9th. Apply each set of bands to one and the same stock and barrel, ascertaining that they go moderately tight only and so nearly alike as to make good and close work—then apply one and the same set of bands to all the arms and ascertain the same points with each, and that the bands fit well to the stocks and barrels and to the band springs.

10th. Apply all the barrels, with one and the same set of bands, to one and the same stock, putting the bands fully to their places to ascertain that they go neither too tight nor too loose, which will be the case when they admit of being shoved by the hand to within a quarter of an inch of their respective places; ascertain that the supporters fit the stocks and the butt pieces—then apply one and the same barrel with the same set of bands to each of the stocks, observing the same particulars.

11th. Ascertain that the supporters are securely fastened to the barrels with two screws in each and with good solder over the whole extent of the supporter where it comes in contact with the barrel—to determine this point, put a little oil above the junction of the supporter and the barrel, then grasp both supporters with one hand, holding the barrel with the other, and spring them inwards

several times; if the soldering is not sound, the oil will be seen to issue from between the supporters and the barrel.

12th. Test the guides and the stops, ascertaining that they slide equally easy in their respective dove-tails in all the barrels, first applying all of each to one barrel and then one of each to all the barrels.

13th. Examine the receiver and the various parts attached to it by applying in the first place all the batteries, with each a spring attached, to one and the same receiver, ascertaining that each one shuts fairly down on the pan leaving a little space open between it and the front edge of the pan, sufficient to admit of one thickness of common cap paper; then apply one and the same battery to all the pans, putting in the battery screw; and thus proceed to test the accuracy of all the different parts of the lock attached to the receiver, applying all of the different component parts to one and the same receiver and one of each of the component parts to all the receivers.

GENERAL DIRECTIONS.

The inspector is not restricted to the particular examinations above-mentioned; he will make any other examinations which he may deem necessary to ascertain the quality of any part of the arms and their conformity to the standard models; if he discovers or suspects any attempts on the part of the workmen to cover or conceal serious defects, he will subject the arms to the most severe scrutiny, in order to detect such defects.

In the inspection of contract arms, the inspector will judge of the quality of materials and workmanship by the rules which govern in like cases at the national armories; that is, he will reject such arms or parts of arms as would be condemned at the national armories, and he will receive such as would be approved at the national armories; without exacting, in any case, more rigid conditions than are enforced at those establishments.

The ordnance officer charged with the inspection of arms, or the master armorer at a national armory, will cause at least *one in twenty* of each lot of arms passed by a sub-inspector to be taken to pieces in his presence, and he will examine them strictly agreeably to the foregoing directions before affixing his stamp of approval on the finished arms, all of which must be examined by him.

MARKS: As a general rule, every part condemned on inspection will be indelibly marked with the letter *C*, and every principal part approved will be marked with the initials of the inspector's name. Care must be taken that the marks of approval are not stamped so deep as to be injurious.

Finished arms approved on inspection will be marked on the left face of the stock with the initials of the name of the principal inspector, and the year of inspection.

BROWNED ARMS.

The barrels and mountings of rifles and carbines are browned at the armories before being received for the service; the *locks, ramrods, band springs, bayonets* for 6 in. from the points, *triggers, receivers* and *screws* are not browned. The parts of these arms should be thoroughly inspected before browning, and the finished arm after being browned.

*Instructions for Browning Arms.**Materials for Browning Mixture.*

1½ oz. spirits of wine.

1½ oz. tincture of steel.

½ oz. corrosive sublimate.

1½ oz. sweet spirits of nitre.

1 oz. blue vitriol.

¾ oz. nitric acid.

To be mixed and dissolved in 1 quart of soft water—the mixture to be kept in *glass bottles* and not in earthen jugs.

Previous to commencing the operation of browning, it is necessary that the barrel or other part should be made quite bright with emery or a fine smooth file, (but not burnished,) after which it must be carefully cleaned from all greasiness; a small quantity of pounded lime rubbed well over every part of the barrel is the best for this purpose. Plugs of wood are then to be put into the muzzle of the barrel and into the vent, and the mixture applied to every part with a clean sponge or rag. The barrel is then to be exposed to the air for twenty-four hours; after which time, it is to be well rubbed over with a *steel scratch card* or *scratch brush*, until the rust is entirely removed; the mixture may then be applied again, as before, and in a few hours the barrel will be sufficiently corroded for the operation of scratch brushing to be repeated. The same process of scratching off the rust and applying the mixture is to be repeated twice or three times a day for four or five days, by which time the barrel will be of a very dark brown color.

When the barrel is sufficiently brown and the rust has been carefully removed from every part, about a quart of boiling water should be poured over every part of the barrel, in order that the action of the acid mixture upon the barrel may be destroyed and the rust thereby prevented from rising again.

The barrel, when cold, should afterwards be rubbed over with linseed oil or sperm oil. It is particularly directed that the steel scratch card or scratch brush

be used in the place of a hard hair brush, otherwise the browning will not be durable nor have a good appearance.

The browning mixture is applied to other parts of arms in the same manner as to the barrels.

PACKING SMALL ARMS.

Box for 20 Muskets. Plate 12.

Packing boxes for muskets are made of well seasoned pine boards 1 in. thick; the sides and bottom lap over the ends; in each corner is a piece $1\frac{1}{4}$ in. thick by $2\frac{3}{4}$ in. wide, of the whole depth of the box; the *side* of the corner piece is placed against the *end* of the box, and it has a $\frac{1}{2}$ in. rabbit on the inner angle, into which is fitted a board 1 in. thick, flush with the inner face of the corner piece, which forms the *lining* of the ends; the linings are fastened by three 8*d* nails to each corner piece; the lining of one end is the whole depth of the box, that of the other end extends to within $3\frac{1}{2}$ in. of the top, where its place is supplied by a board $\frac{1}{8}$ th of an in. thick, $3\frac{1}{2}$ in. wide, and of a length equal to the width of the box; it is let into the corner pieces its whole thickness and fastened to each of them by three 4*d* nails, and forms a compartment for the implements.

The interior dimensions of the box are: length (between the end linings) 4 ft. $10\frac{1}{2}$ in.; width, $15\frac{3}{4}$ in.; depth, $12\frac{5}{8}$ in.

The *ends* are fastened by eight 8*d* nails in 2 rows in each corner piece: each *side* is fastened by five 12*d* nails in each end, three 10*d* nails and one 2 in. screw No. 14, (above the nails) in each corner piece—the *bottom* is fastened by four 10*d* nails in each end, one 10*d* nail and two 2 in. screws No. 14, in each side—the top is fastened by two 2 in. screws in each end, and 4 in each side.

Two holes are bored in each end, 7 in. apart and $8\frac{1}{2}$ in. from the bottom of the box, to receive *beckets* of rope $\frac{1}{2}$ in. diameter and 18 in. long, which must be inserted and fastened by a countersunk knot before the end linings are nailed on.

In each side of the box are 4 rectangular *grooves*, the whole depth of the box, 1 in. wide and $\frac{1}{2}$ in. deep; two of them are close to the inner sides of the corner pieces; the other two, 10 in. from these, measuring from centre to centre.

The *packing stuff* consists of the following parts:

1st. The *bayonet board* $15\frac{3}{4}$ in. long, 7 in. wide, and $7\frac{1}{8}$ in. thick in the middle, chamfered at the edges; in each edge there are 10 rectangular notches with circular terminations, 1 in. deep and $1\frac{1}{2}$ in. wide, placed $1\frac{1}{2}$ in. apart, the first notches $1\frac{1}{2}$ in. from the alternate ends of the board. This board is fixed in the centre of the box, $1\frac{1}{2}$ in. from the bottom, by two 10*d* nails driven into each end through the side of the box.

2d. 6 *bearing boards*, 3 for each of the two inner grooves. For their forms and dimensions, see *Plate*, (section on *C. D.*)

3d. 24 *wedges*; they are all 1 in. thick and each of them has a $\frac{1}{2}$ in. rabbit at the top and bottom on the same face; 4 of them are like *No. 1*, 4 like *No. 3*, the other 16, like *No. 2*, *Plate 12*.

4th. 2 *clamps*, both $16\frac{1}{4}$ in. long and 1 in. thick, with a $\frac{1}{2}$ in. rabbit on the side; one of them is 1 in. wide, the other $2\frac{7}{8}$ in.

The above dimensions are calculated for the model of 1822; some modifications will be required to adapt them to the model of 1840.

To pack a Box of Muskets.

Unfix the bayonets, open the pans and let down the cocks; put the sockets of the bayonets under the bayonet board, 10 on each side, the shanks resting in the notches in the edge of the board; then place the two lower bearing boards each with the bevel towards the nearest end of the box, the notches in the lower edge being over the points of the bayonets and pressing them against the bottom of the box.

Place the first musket with its side plate against the side of the box, the stock resting between the upper and middle band in the groove of the bearing board; complete the lower tier of 10 muskets, their butts resting alternately against the lining of the ends; insert one of the wedges *No. 3* between the butt of the first musket and the side of the box, in the groove nearest to the lining; insert one of the edges *No. 2* between the butts of each two contiguous muskets, the lower rabbit entering between the end lining of the box and the muzzle of the intermediate musket; place the wedge *No. 1* in the groove opposite to the first, trimming it if necessary, to keep all the muskets tight at that end; secure them at the opposite end of the box in the same manner and put in the two narrow clamps over the lower tier of wedges, the rabbits fitting in each other. Next insert the two middle bearing boards, the lower grooves fitting on the handles of the stocks. Place the second tier of 10 muskets in the same manner as the first and put in the upper tier of wedges, clamps and bearing boards. Put the implements in the pocket provided for them and screw on the cover.

Packing Arms with Straw.

In the field, or under other circumstances when the proper arm chests are not on hand, it may sometimes be necessary to pack arms in this manner.

The interior dimensions of a box for 20 muskets may be the same as for the regular packing box.

The straw should be long, perfectly dry and free from dust; *rye straw* is the best; *hay* should never be used: about 25 lbs. of straw are required to a box.

To prepare the muskets for packing: oil them; let down the cock, pass the bayonet up to the socket into the guard bow, on the right side, in front of the trigger. Make a rope of about 40 straws, slightly twisted and 40 in. long; wrap it about the musket commencing on top of the cock and behind the battery, going round the bayonet below, again over the cock and battery and round the piece in front of the guard, then over the socket of the bayonet near the neck, and wrapping the rest around the handle of the stock.

Lay a bed of straw 2 in. thick in the bottom of the box; in the middle and at 6 in. from the ends, place three cushions of straw 6 in. thick and 12 in. wide.—Put in a tier of 10 muskets crossing each other, the butts resting alternately against the ends of the box, the guards uppermost and the cocks bearing on the cushions. Put small trusses of straw under the upper and middle bands, by raising the muskets at one end and then pressing them down between the others. Pack, between the butts, wads of straw 8 in. long, made of a handful of straws folded in three; cover the guards and guard bows with the ends of the straw that forms these wads, which will be still about 12 in. long. Put in another tier of 10 muskets in the same manner, making the cushions 4 in. thick. Pack the implements in straw in the vacant spaces. Fill the box with straw, so that the cover shall require strong pressure to keep it down. Put two hoops round the box, at 18 in. from the ends.

Other arms, swords, &c. are packed in a similar manner.

Arms should not be wrapped in paper unless it be oiled, as it attracts moisture more readily than straw does.

PRESERVATION OF ARMS IN STORE.

Arrangement and Manner of Storing Arms.

Arms are kept at the Arsenals either in the boxes in which they are received from the armories, or in racks.

Those of each kind are kept separate and they are arranged according to the model, the place and year of fabrication, and the time when they were last cleaned.

New arms are kept distinct from those which have been repaired.

Each parcel should have a label indicating the kind, number, model, date of their receipt in store, and of their being last cleaned.

The manner of keeping arms at the arsenals is determined by the chief of the Ordnance Department, according to the peculiar circumstances of each case, and

racks are constructed for them only in pursuance of special authority from the Ordnance office; without such authority they are kept in boxes. The form and arrangement of the racks vary with those of the room in which they are placed, so as to use the space to the best advantage and give light and air to every part of the room. The usual arrangement of racks for muskets is to establish two rows of double racks, two tiers high, perpendicular to the length of the room, leaving alleys around the room next to the walls and in the centre if necessary. The bayonets are passed through the middle band swivel, the socket covering the top of the ramrod. Other racks of a similar kind may be made for *rifles, carbines, &c.* *Pistols* are suspended by the guard bow on hooks driven into the faces of the musket racks, or into the joists, or into strips attached to the walls of the building.

When there are neither racks nor boxes prepared, the arms are stored in dry rooms, arranged in rows apart from the walls, standing on their muzzles and supported by frames to prevent them from pressing too much on each other. The bayonets should be unfixed and passed through the swivel. They should be covered with tarpaulins or cloths, if necessary, to protect them from dust.

Arms of peculiar kinds and arms to be repaired, are kept separate from others; as also arms unserviceable or condemned to be broken up.

Limbs and spare parts intended for repairs of arms should be kept in store by themselves, in a dry place, classed according to the kind of arms and to the model and year of fabrication, and labeled accordingly.

Musket and *rifle barrels* and other long barrels, standing on their muzzles, the piles covered from the dust with tarpaulins supported so as not to touch the barrels. *Pistol barrels, bayonets* and other small parts, in drawers or boxes properly labeled. *Stocks*, in square piles, in the attic or upper story of the building.

Care of Arms in store.

Arms when received at an arsenal should be unpacked and carefully examined, to detect any damage suffered in transportation; they should be cleaned and oiled, if they require it. Those arms which are not to be placed in racks should be returned to the boxes, laid in loosely but safely, and the cover slightly fastened down, so that they can be readily examined.

All arms in store should be frequently examined, to see that they do not become rusty. Those which are found to be rusted should be immediately cleaned and again oiled. Browened arms, if affected with specks of rust, should be rubbed hard with linseed oil, and if the appearance of the browning indicate that the acid is not neutralized, care should be taken to examine the arms again with-

in a short time, as it may be found necessary to remove and renew the browning; but this operation should not be performed without special authority from the chief of the Ordnance Department, on the report of a duly authorized inspector.

Arms which are to be repaired should be oiled and taken care of in the same manner as serviceable arms. Irreparable arms, the parts of which can be used for repairs, should be oiled. Similar remarks apply to spare parts for repair of arms.

Spermuceti oil should be used for greasing arms.

Empty boxes from which the arms in racks are taken should be kept with all the parts belonging to them in the attics or other dry situations.

The store houses for arms should be aired in clear dry weather.

Issuing Arms.

The Ordnance Regulations prescribe the manner of issuing arms to the troops, under the various circumstances of service, and to the States, for arming the militia.

All arms issued from an arsenal should be carefully examined before delivery, cleaned and put in good order; if intended for transportation, they should be oiled, if necessary, after cleaning, and carefully packed.

PRESERVATION OF ARMS IN SERVICE.

The officers, non-commissioned officers and soldiers should be instructed and practised in the nomenclature of the arms, the manner of dismounting and mounting them, and the precautions and care required for their preservation.

Each soldier should have a screw driver and a wiper, and each squad of 10, a wire and tumbler punch and a spring vice. No other implements should be used in taking arms apart or in setting them up.

In the inspection of arms, officers should attend to the qualities essential to service, rather than to a bright polish on the exterior of the arms. The arms should be inspected in the quarters at least once a month, with the barrel and lock separated from the stock.

Taking Arms to pieces.

Order in which the parts of the musket should be taken off.—1. The bayonet—2. The ramrod—3. The side screws—4. The side plate—5. The lock—6. The upper band—7. The upper band spring—8. The middle band—9. The middle band spring—10. The trigger wire—11. The trigger—12. The tang screw—13. The lower band—14. The lower band spring—15. The barrel—

16. The guard screws—17. The guard—18. The butt plate screws—19. The butt plate.

In the musket of the model of 1840, the trigger screw and trigger are taken off after the guard, then the pin for the ramrod spring and the ramrod spring.

Order in which the lock is taken apart.—First let down the cock. 1. The main spring screw—2. The main spring (after compressing it with the spring vice)—3. The sear spring screw (before turning this screw entirely out, strike the elbow of the spring with the screw driver, so as to disengage the pivot from its mortice)—4. The sear spring—5. The sear screw—6. The sear—7. The bridle screw—8. The bridle—9. The tumbler screw—10. The tumbler (it is driven out with the punch inserted in the screw hole)—11. The cock—12. The battery screw, (after compressing the battery spring with the spring vice)—13. The battery—14. The battery spring screw—15. The battery spring—16. The pan screw—17. The pan—18. The flint screw—19. The upper jaw.

The lock and the musket are put together in the inverse order of taking them apart.

The flint screw has a hole through the head; the tumbler screw has a larger head than any other lock screw; the pan screw has a flat countersunk head. The other six screws are distinguished by their lengths, which are in the following order, beginning with the shortest, viz: 1. Main spring screw—2. Sear spring screw—3. Bridle screw—4. Battery spring screw (nearly equal in length to the bridle screw)—5. Sear screw—6. Battery screw. The two side screws are of nearly equal length; the point of the rear one is flat, that of the front one rounded. There are three sizes for the threads of these screws; the first and largest for the flint screw; the second, for the side screws and the battery screw; the third for all the others.

Before replacing a screw, put a small drop of *sperm oil* in the screw hole or on the point of the screw: put a drop of oil also on the arbor and pivot of the tumbler; between the moveable branches of the springs and the lock plate; on the hook and notches of the tumbler and on the toe of the battery, after the lock is put together. Take care that the screws are not turned in too hard, so as to make the limbs bind; to insure this, try the motion of each limb before and after its spring is mounted and see that it moves freely without friction.

The soldier should never take the lock apart, or take off the guard, except when a non-commissioned officer considers it necessary. The band and rod springs, and the butt plate should not be taken off unless it is impossible to clean them in place. The breech screw should be taken out only by an armorer, and *never* in ordinary cleaning.

Cleaning and care of arms.

For the iron and steel parts when much rusted, use fine emery, sifted and moistened with oil; when slightly rusted, use rotten stone or brick dust sifted very fine, moistened likewise with oil. For the brass parts use rotten stone or fine brick dust moistened with vinegar or water; these parts should not be greased. Make use of a hard brush, or a piece of soft wood, such as white pine or cedar. Remove the dirt from the screw holes by screwing a piece of soft wood into them. Wipe the parts clean with a linen rag, (leaving *a little oil* on the inner parts of the lock,) but never *burnish* them.

To clean the exterior of the barrel, lay it flat on a bench or table or piece of board, in order to avoid bending it. The practice of cleaning a bright barrel by supporting it at the two ends and rubbing it with a strap or buff stick, or with the ramrod to burnish it, is highly pernicious and should be strictly prohibited. After firing, the barrel should be always washed; when the water comes off clear, wipe the barrel dry, and then pass into it a rag moistened with oil.

To take off the barrel: after removing the bands and the tang screw, hold the stock and barrel lightly with the left hand, about 6 inches from the breech, the barrel down, with the muzzle about an inch from the ground; strike with the right hand on the handle of the stock until the barrel is disengaged from its groove, supporting the barrel with the left hand until it can be seized by the right hand and separated from the stock.

It is very important to use no other implements than those beforementioned. By using nails to drive out the wires, their holes are enlarged; and by using the point of the bayonet or of the ramrod for taking off the battery, the pan is defaced, and perhaps the ramrod broken. The main spring should never be heated for the purpose of either raising or lowering its temper; this destroys the elasticity of the spring and the lock no longer gives fire. The notches of the tumbler, the hook of the main spring, the toe of the battery, and in general, all the joints of the lock, should be frequently oiled, after first wiping off the hard grease and the dust. Fix the flint with care, the bevel uppermost, and the edge parallel to the face of the battery; the flint cap should not project much beyond the jaws of the cock. When the flint becomes dull, renew the edge by striking gently with the screw driver on the upper side, supporting it underneath with the forefinger of the left hand, in order to avoid breaking off too much. When the flint is worn so as not to project more than a quarter of an inch beyond the jaws, it must be set forward, or a new one substituted.

Browned arms are cleaned by rubbing them hard with an oiled rag until the oil is well incorporated with the browning ; or by rubbing them with bees-wax on a rag or cork.

Care of Hall's arms.

The peculiar construction of these arms renders it necessary to observe certain precautions in the use of them, besides those which are required generally for the preservation of small arms.

To take the arm apart. Turn out the front side screw and remove the receiver, then turn out the other two side screws, loosen the bands and take off the barrel. The order in which the other mountings are detached from the stock is not important.

To take the lock apart. Detach the limbs in the following order ; 1, the battery spring screw ; 2, the battery spring ; 3, the battery screw ; 4, the battery ; 5, the sear spring screw ; 6, the sear screw ; 7, the sear ; 8, the sear spring ; 9, the main spring screw, (after compressing the main spring with the spring vice and detaching it from the link ;) 10, the main spring ; 11, the cock screw ; 12, the cock ; 13, the flint screw ; 14, the upper jaw ; 15, the link screw ; 16, the link.

To put the arm together. The mountings are attached to the stock before the barrel is put in, observing that the butt piece and screw should not be turned in hard until the barrel is in place.

To put the lock together. Place the sear spring and turn its screw loosely in ; put in the main spring and its screw, and then, the cock ; hook the link to the main spring with the aid of the spring vice ; put in the sear and its screw, and then turn in the sear screw and sear spring screw tight. The other limbs are put together in the inverse order of taking them apart. The flint screw, the cock screw, the sear screw and the battery screw should be turned in very tight ; the other screws are left rather loose.

By turning the set screw, which passes through the sear and bears against the cock, the action of the trigger may be regulated so as to make the lock go easy or hard : the action of the battery spring is also regulated by turning its screw.

The greatest attention must be paid to the chocks by which the recoil of the receiver is checked, and the opening between it and the barrel regulated. This opening should be such as to admit one thickness of common writing paper and to bind two thicknesses ; if the opening becomes, from any cause, too great, it may be diminished by inserting a thin slip of metal in the notch of the supporter, behind one chock or both, as may be required.

The shoulders of the receiver must always bear firmly against both chocks : *the piece should never be fired without the chocks being in place*, as in that case

the opening between the receiver and the barrel becomes much too great, a part of the charge is perhaps lost, the effect of the remainder much lessened, and the stock almost inevitably destroyed by the blast and by the undue strain which it suffers from the recoil of the receiver.

If by frequent firing the receiver becomes foul, so as to close with difficulty, or not to admit the ball readily, its easy action may be restored by slightly wetting it and wiping the bore with the finger, and the muzzle with the palm of the hand.

INSPECTION OF ARMS IN SERVICE, OR WHICH HAVE BEEN IN SERVICE.

Implements. Standard and limit gauges for the bore, limit gauges for the exterior of the barrels, and a screw plate with taps for the holes of the lock plate.

The following are the principal points to be attended to in the inspection of arms:

1st. The arms being taken to pieces and cleaned.

BARREL. *Defects for which the barrel must be condemned as unfit for service.* The large gauge entering the whole length of the barrel. The small or standard gauge not entering, unless the diminution of the bore is caused by the barrel being indented or bent, defects which may be remedied. A diminution of the exterior diameter at the breech or at the muzzle, so as to enter the small receiving gauges: this diminution is 0.1 in. at the breech; 0.03 in. at the muzzle for arms with bayonets, and 0.045 in. for arms without bayonets. A diminution of more than 0.25 in. in the length of a pistol barrel, or 0.5 in. in the lengths of other barrels. Splits, cross cracks and other serious defects, caused either by bad workmanship or by use.

Examine the barrel carefully to see if it has any of the above defects, and if so, mark them with a file, when not very apparent—see if the bayonet stud is broken or too much worn—if the vent is enlarged more than 0.03 in.—if the vent has been bouched, see that its direction is good, and that the bouche is flush with the surfaces of the barrel and bore. If the breech screw is not tight after entering 5 or 6 threads, or if it can be screwed down by hand without the use of a wrench—if the threads are not sharp and sound—if the plug does not fill up the whole box of the female screw—if the tang is broken or cracked at the screw hole—or if, when the breech screw is in, the tang is not even with the upper surface of the barrel, a new breech screw is required.

BAYONET. A bayonet is considered unserviceable if the blade is 1 inch too short—see if it is sound and perfect in all its parts and if it fits the barrel. Note the defects.

Lock. See if the fixed branches of the *springs* fit close to the lock plate, and if the moveable branches are clear of it.

When the *battery spring* (of the model of 1840) does not uncover the hole for the side screw, replace it or set it more open, as may be required.

Have the springs and the bridle of the tumbler renewed when their pivots are broken. There should be an equal space between the lock plate and the sear, the tumbler and the cock.

If the *sear* rubs on the plate, have it adjusted. The friction of the *tumbler* may be caused by the bridle being badly pierced, in which case renew the bridle. If the *cock* rubs on one side only, have it adjusted; if it rubs every where, the arbor of the tumbler does not project sufficiently and the tumbler should be renewed. If the *notches of the tumbler* are broken or the edges too blunt, have them dressed; if the hook of the tumbler projects beyond the edge of the lock plate when the cock is let down, either the shoulder of the cock is worn or the tumbler is badly made, and one or the other should be renewed. The arbor and the pivot of the tumbler should fit well in their holes. Examine the *sear* closely, and have it renewed when the nose is too thin or is worn on the side next the lock plate, although it may be perfect on the exterior. When the battery does not fit close on the *pan*, have the pan adjusted; when the face of the *battery* is worn, or the toe is too short, renew the limb.

The axis of the flint screw and the chord of the face of the battery should be nearly parallel to each other when the lock is at half cock. When the cock is too near to the battery, put in a sear with a longer nose or else change the tumbler. If the *jaws of the cock* are not parallel, renew the upper jaw. If the *cock* is not steady, renew the tumbler.

Renew the *lock plate* when the holes are too much worn to be dressed over. Renew every limb that is broken or cracked, the screws which are too much worn, or of which the stems are bent, or the slits too much enlarged.

MOUNTINGS. See if the parts are complete and sound.

If the *tang screw* does not fit tight in the screw hole of the guard plate, renew whichever part is defective.

RAMRON. See if it is sound and has a good thread, and is of the proper length; otherwise replace it.

Stock. Examine carefully the *bed of the lock*, and the holes for the band springs. Press the thumb against the *facings*, to see if they are split at the holes for the side screws, and renew the stock if it is split there or at any other part, to an injurious extent.

2d. The arms complete,

Are inspected according to the rules before laid down for the inspection of finished arms; due allowance being made for the necessary wear in service.

REPAIRS OF ARMS AT ARSENALS.

When arms which have been in the hands of the troops are turned into store at an arsenal, they should be inspected by a master armorer, under the supervision of an officer, and classed as follows:

1st. *Serviceable arms.*

2d. *Arms requiring repairs.*

3d. *Irreparable arms.*

Arms requiring repairs are classified according to their kinds and models, and to the extent of the repairs required. Each arm should be marked with a number, and the requisite repairs should be noted on the register of inspection, to guide the workmen and to govern the issue of spare parts required for repairs.

Remarks relative to repairs of arms.

Repairs prohibited. The following repairs being always imperfect, the parts requiring them should be replaced: cutting off a barrel—brazing a patch on a barrel—brazing a tang on the breech screw—brazing a bolster on a lock plate—reaming out the hole for the arbor of the tumbler—brazing a bridle to the pan—brazing a piece for a tumbler hole or a shoulder on the cock—hammering in the edge of the hole to make it fit tight on the square of the tumbler—brazing a toe to a battery—putting a pivot to a tumbler—twisting the square of the tumbler to increase the sweep of the cock—straightening the arbor—brazing a ramrod—splicing a stock.

The spare parts furnished from the armories are in general *filed and finished*, except hardening and tempering. The screws are finished and hardened.

The parts of Hall's arms, being made identical in form and dimensions, are supplied in a finished state.

Fitting new parts. To adjust a new lock, the flat of the barrel should not be filed, but the bolsters of the lock plate should be ground.

The barrel should not be touched with a file unless it is necessary in dressing the flat on the side of the lock, when it has become injured by rust. In replacing the bayonet stud, avoid cutting too deep into the barrel and producing a projection inside; try the small gauge in the barrel after the operation. In fitting a new bayonet, dress out the groove of the bayonet socket and ream out the socket if necessary.

To replace a lock plate, break off the bolsters of the old plate and use it as a gauge for filing and piercing the new one, in order that it may fit well in the stock, &c. *In fitting a cock*, dress out the tumbler hole to make it fit the tumbler; give the shoulder a good bearing, and set the cock parallel to the plate. *In fitting an upper jaw*, dress out the screw hole and the notch to correspond with the other parts of the cock. *In fitting a pan*, preserve the proper inclination of the face, and let the seat of the battery fit close to it. *When it becomes necessary to file the battery*, re-establish the slope, case harden the battery and temper the heel, and *when the face of the battery is worn*, replace the limb if practicable. *In adjusting a tumbler*, dress the square or the notches only, and never diminish the thickness. *In fitting a sear*, adjust the dimensions and curve of the nose according to the set of the tumbler and cock. *To dress a tumbler or a sear*, the limb should be first softened if necessary, and after being fitted, it should be hardened and tempered blue. *In tapping the tumbler, sear and battery screws*, cut them so that they cannot be driven in too far. *In fitting a guard plate, side plate, or butt plate*, do not file away the edges so that they shall not fit the beds.

To bouche a vent. Bore a hole rather smaller than the diameter of the flint screw; tap it with two taps, the first slightly conical, and the second of the size of the flint screw; tap the bouche to the same size, after ascertaining that the metal is perfectly sound; screw it in with a hand vice, flush with the inner surface of the bore, smooth it off, and pass the tap of the breech screw into the barrel; then pierce the vent by means of drills and punches, the last of which has the exact dimensions of the vent, and smooth off the burrs; be careful to bore the vent in the proper direction, dipping a little into the pan. — If the vent has been bouched before, use larger drills.

Braze sights and bayonet studs only, and no other pieces; the solder is composed of two parts of brass and one of zinc, without any tin.

Irreparable Arms.

Arms are considered *irreparable* when both the barrel and stock are unfit for service; or when the arms require very extensive repairs and the parts can be made useful for repairs of other arms. They can be broken up only by special authority, and they should therefore be oiled and preserved, in order to be submitted to an authorized inspector as prescribed in the regulations of the Ordnance Department.

When arms are broken up, the parts are classed either as *serviceable*, *reparable*, or *unserviceable*; those of the last class should be turned into store as *scrap iron or steel*, &c.

Number and kind of Armorer's Tools required for any number of workmen, from 1 to 12, at an Arsenal for repairs.

NUMBER OF WORKMEN -		1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.													
Awls—wire	-	3	3	3	3	3	3	6	6	6	6	6	6
Band-sets, for muskets, rifles and pistols	-	1	1	1	1	1	1	2	2	2	2	2	2
Brace, drill, } Iron	-	1	1	1	1	1	1	1	1	1	1	1	1
Brace, hand, }	-	1	2	3	4	5	6	7	8	9	10	11	12
Bits—ramrod	-	3	3	3	3	3	3	6	6	6	6	6	6
“ centre	for do.	6	6	6	6	6	6	12	12	12	12	12	12
“ chambering	-	3	3	3	3	3	3	3	3	3	3	3	3
“ bayonet boring	-	1	1	1	1	1	1	1	1	1	1	1	1
“ side screw,	for do.	3	3	3	3	3	3	6	6	6	6	6	6
“ guard screw	do.	3	3	3	3	3	3	6	6	6	6	6	6
“ butt screw	do.	3	3	3	3	3	3	6	6	6	6	6	6
Bolsters, cock and tumbler,	do.	2	2	2	2	2	2	4	4	4	4	4	4
Brushes, hard	-	2	2	2	2	2	2	4	4	4	4	4	4
Brushes, hand (bench)	-	1	1	1	1	1	1	2	2	2	2	2	2
Callipers, pairs	-	1	1	1	1	1	1	2	2	2	2	2	2
Centre punch	-	1	2	3	4	5	6	7	8	9	10	11	12
Chisels, cold	-	3	6	9	12	15	18	21	24	27	30	33	36
Chisels, stocker's	-	12	12	12	12	12	12	24	24	24	24	24	24
Chisels, bottoming or foot	-	2	2	2	2	2	2	4	4	4	4	4	4
Compasses, pairs	-	1	1	1	1	1	1	2	2	2	2	2	2
Countersinks, pairs	-	3	6	9	12	15	18	21	24	27	30	33	36
Clamps, spring,	for do.	3	3	3	3	3	3	3	3	3	3	3	3
Clamps, for bands	do.	2	2	2	2	2	2	2	2	2	2	2	2
Clamps for swivels	do.	3	3	3	3	3	3	3	3	3	3	3	3
Drill-bow	-	1	1	1	1	1	1	2	2	2	2	2	2
Drills, assorted	-	12	12	12	12	12	12	24	24	24	24	24	24
Dies, sets	-	9	9	9	9	9	9	9	9	9	9	9	9
Drifts, cock	-	3	3	3	3	3	3	6	6	6	6	6	6
Dividers, spring	-	1	1	1	1	1	1	1	1	1	1	1	1
Floats, barrel and rod,	for do.	3	3	3	3	3	3	6	6	6	6	6	6
Fleams, (or sliders)	-	2	2	2	2	2	2	4	4	4	4	4	4
Files, assorted	-	12	24	36	48	60	72	84	96	108	120	132	144
Glue pot	-	1	1	1	1	1	1	1	1	1	1	1	1
Gauges, stocker's	-	12	12	12	12	12	12	24	24	24	24	24	24
Grinders, assorted	-	30	30	30	30	30	30	30	30	30	30	30	30
Gauges, lock,	for do.	8	8	8	8	8	8	8	8	8	8	8	8
Hooks, spring	-	1	2	3	4	5	6	7	8	9	10	11	12
Hammers, bench	-	2	4	6	8	10	12	14	16	18	20	22	24
Knives, drawing, (stocker's)	-	2	2	2	2	2	2	4	4	4	4	4	4
Levelers	-	2	2	2	2	2	2	4	4	4	4	4	4
Mandrils, swivel,	for do.	1	1	1	1	1	1	1	1	1	1	1	1
Mandrils, band, sets of	-	3	3	3	3	3	3	3	3	3	3	3	3
Nippers, pairs	-	1	2	3	4	5	6	7	8	9	10	11	12
Pliers, pairs	-	1	1	1	1	1	1	2	2	2	2	2	2
Planes, assorted, stocker's	-	7	7	7	7	7	7	14	14	14	14	14	14
Reamers,	for do.	12	24	36	48	60	72	84	96	108	120	132	144
Rods, wiping	-	1	1	1	1	1	1	2	2	2	2	2	2
Rods, rifling	-	1	1	1	1	1	1	2	2	2	2	2	2
Rifflers	-	2	2	2	2	2	2	4	4	4	4	4	4
Stake	-	1	2	3	4	5	6	7	8	9	10	11	12
Saws, hack	-	1	2	3	4	5	6	7	8	9	10	11	12
Stocks, tumbler, pairs	-	1	1	1	1	1	1	1	1	1	1	1	1
Stocks, die	-	2	2	2	2	2	2	2	2	2	2	2	2
Stocks, drill	-	1	1	1	1	1	1	2	2	2	2	2	2

NUMBER AND KIND OF ARMORER'S TOOLS—Continued.

NUMBER OF WORKMEN	1	2	3	4	5	6	7	8	9	10	11	12
TOOLS.												
Set-punch	1	2	3	4	5	6	7	8	9	10	11	12
Scraper, barrel—musket, rifle and pistol	2	2	2	2	2	2	4	4	4	4	4	4
Screw-drivers	3	6	9	12	15	18	21	24	27	30	33	36
Screw plates	3	3	3	3	3	3	3	3	3	3	3	3
Squares, iron	2	2	2	2	2	2	2	2	2	2	2	2
Tools for punching bayonet sockets, set	1	1	1	1	1	1	1	1	1	1	1	1
Tongs, pairs	7	7	7	7	7	7	7	7	7	7	7	7
Taps, flint screw—musket, rifle and pistol	6	6	6	6	12	12	12	12	18	18	18	18
Taps, small lock do.	6	6	6	6	12	12	12	12	18	18	18	18
Taps, battery do.	6	6	6	6	12	12	12	12	18	18	18	18
Taps, side do.	6	6	6	6	12	12	12	12	18	18	18	18
Taps, breeching do.	9	9	9	9	9	9	9	9	9	9	9	9
Vices, barrel	1	1	1	1	1	1	1	1	1	1	1	1
Vices, bench	1	2	3	4	5	6	7	8	9	10	11	12
Vices, hand	1	2	3	4	5	6	7	8	9	10	11	12
Wrenches, hammer and tumbler—musket, rifle and pistol	3	3	3	3	3	3	6	6	6	6	6	6
Wrenches, breech and tap	4	4	4	4	4	4	4	4	4	4	4	4
Wrenches, flint screw	1	2	3	4	5	6	7	8	9	10	11	12

Spare parts required for the repair of 1000 Muskets (model of 1822) during one year in the field.

Barrels	10	Small lock screws	1000
Breech screws	20	Side screws	200
Tang screws	50	Side plates	50
Bayonets	50	Upper bands	75
Locks	2	Middle bands	50
Lock plates	6	Lower bands	50
Pans	30	Band springs	100
Batteries	100	Trigger plates	10
Battery springs	100	Guards	10
Cocks	50	Guard screws	150
Upper jaws	80	Swivels	150
Flint screws	200	Triggers	25
Tumblers	50	Butt plates	5
Bridles	25	Butt plate screws	50
Sears	40	Ramrods	120
Sear springs	125	Stocks	100
Main springs	150		

About one-fourth of the above number of parts is required for the repair of 1000 pistols, omitting such as do not belong to the pistol.

Hall's Rifles Spare parts required for the repair of 1000 or Carbines, (Old model) during one year in the field.

	Rifles.	Carbines		Rifles.	Carbines
Barrels - - -	10	10	Links - - -	100	100
Guides - - -	50	50	Link screws - - -	50	50
Bridges - - -	-	20	Stops - - -	60	60
Bayonet springs - - -	-	100	Aprons - - -	10	10
Supporters - - -	16	16	Apron screws - - -	20	20
Supporter screws - - -	32	32	Catches - - -	60	60
Chocks - - -	150	150	Catch screws - - -	75	75
Chock screws - - -	200	200	Catch springs - - -	30	30
Receivers - - -	10	10	Catch spring screws - - -	50	50
Butt pieces - - -	10	10	Upper bands - - -	20	20
Butt piece screws - - -	25	25	Middle bands - - -	20	-
Side screws - - -	150	150	Lower bands - - -	20	20
Batteries - - -	25	-	Band springs - - -	50	50
Battery screws - - -	50	-	Catch plates - - -	10	10
Battery springs - - -	60	-	Catch plate screws - - -	30	30
Battery spring screws - - -	50	-	Guard plates - - -	10	10
Nipples - - -	-	150	Guard bows - - -	10	10
Cocks - - -	50	50	Guard screws - - -	50	50
Cock screws - - -	50	50	Swivels and rivets - - -	100	100
Upper jaws - - -	25	-	Box plates - - -	-	5
Flint screws - - -	150	-	Box plate springs - - -	50	50
Sears and triggers - - -	50	50	Box catch springs - - -	50	50
Sear screws - - -	30	30	Butt plates - - -	10	10
Sear springs - - -	50	50	Butt plate screws - - -	50	50
Sear spring screws - - -	50	50	Bayonets - - -	20	} 20
Set screws - - -	30	30	Ramrods - - -	50	
Main springs - - -	75	75	Stocks - - -	100	100
Main spring screws - - -	50	50			

For the repair of arms in the hands of troops in garrison, take about one-half of the number of parts required for arms in the field.

Spare parts required for repairs, if not obtained from arms that are broken up, are supplied from the armories, on requisitions made in the manner pointed out by the regulations of the Ordnance Department.

Durability and strength of Musket Barrels.

The United States musket of the model of 1840, being copied from the French musket, the following remarks relative to the latter, (extracted from the *Aide Memoire*, 1836) will apply to the former. It is to be observed also, that the charge of the French musket is 162 grains Tröy, priming included, (or 146

grains, exclusive of priming,) and is therefore considerably greater than our present service charge.

The regulation fixing the duration of small arms in the French service, at 50 years, is founded on the durability of the barrel which is the most important part of those arms. Experience has shown that a musket barrel will bear 25,000 discharges without becoming unserviceable, and even in time of war a musket is not fired more than 500 times a year. The wear caused by firing is therefore small, and the principal cause of the rejection of barrels is the diminution of 0.09 in. in the diameter at the breech. With good management and care, that diminution will take place very slowly, and it ought not generally to occur in the space of 50 years.

It has also been ascertained, by direct trials, that the strength of the barrel furnishes every requisite security against the accidents of service and the want of care on the part of the soldier; and that, even after being reduced in diameter 0.09 in. at the breech, it is still perfectly safe against the effect of the charge. In experiments made in 1806, barrels reduced 0.13 in. at the breech bore a double and triple charge with one ball, or 2 cartridges placed one over the other.

Other trials were made in 1829, at the manufactory of Mutzig, on arms sent there for repairs, which had been a greater or less time in the hands of the troops. They furnished the following results:

1st. When a musket barrel is charged with a single cartridge, placed in any part of it, or with 2 or even with 3 cartridges inserted regularly, without any interval between them, there is no danger of bursting; with 4 cartridges, inserted regularly over each other, or with 2 or even 3 cartridges placed over each other with slugged balls, (or balls *driven* in, as in a rifle,) there is danger only in case of some defect of fabrication, or some deterioration in the barrel—with more than 4 cartridges inserted regularly over one another, or with 2, 3 and 4 cartridges with intervals between them, it is not safe to fire.

2d. No danger of bursting is occasioned by leaving a ball-screw in the barrel. There may be danger from a plug of wood driven tight into the muzzle, when the barrel has been loaded with 2 cartridges; or from a cork rammed into the barrel to a certain distance from the charge.

Snow, clay and sand, which may be accidentally introduced into the barrel are not dangerous if they lie close to the charge; but they are so, when there is a space between them and the charge; in this case sand is the most dangerous, then clay and snow.

Balls or pieces of iron inserted over the charge, were not attended with danger when placed close to the charge, even when their weight amounted to $1\frac{1}{4}$ lb.;

but there is danger from pieces of iron 0.5 in. square, weighing $\frac{1}{4}$ lb., if placed 20 inches or more from the breech.

3d. A barrel with a defect which might have escaped the inspector at the armory, bore the explosion of 3 cartridges regularly inserted. After mutilation which may have caused a reduction of metal in some parts, it may still be used without danger.

Finally, the diminutions of exterior diameter which may be produced in ordinary service are never sufficient to be dangerous. In these trials, barrels originally 0.272 in. thick at the breech, did not burst when loaded with 2 cartridges until the thickness was reduced to 0.169 in., and with one cartridge, to 0.091 in.

SWORDS AND SABRES.

NOMENCLATURE.

Cavalry sabre—Model of 1840—Plate 11.

BLADE. Shoulder, back, edge, bevel, point, curvature, large groove, small groove; *tang*, riveting.

HILT. *Surmounting* (brass,) notch for the guard, back, rivet cap, hole for the tang of the blade—*gripe*, wooden body (birch or maple,) leather covering (calf skin blackened), wires (brass,) notch for the guard, ridges, shoulder, hole for the tang of the blade—*guard*: *front branch*, hook; *back branch*; *middle branch*; *plate*, mortice for the tang, flange, beed, lip.

SCABBARD. (Sheet steel)—*Body*, back, front, sides, holes for the rivets—*Mouth piece*, rim, springs, rivet holes; 2 *rivets*—2 *Bands*, knob, eye for the ring—2 *Rings*—*Tip*, front branch, back branch.

The same sabre, with gilt mountings, for cavalry officers.

Sabre for Mounted Artillery—Model of 1840—Plate 11.

BLADE. With but one groove.

HILT. *Guard*, one branch terminating in a scroll; the plate has 2 counter-sinks, one for the gripe, the other for the scabbard.

SCABBARD. *Spring*, fastened to the back by 1 *rivet*—no mouth piece.

In other respects the nomenclature is the same as that of the cavalry sabre.

The same sabre, with ornamented gilt mountings, for mounted officers of artillery and infantry.

Foot Artillery Sword—Plate 11.

BLADE. Straight, two edged, narrower nearer the hilt than in the middle—*Body* (or blade proper,) shoulder, shoulder rounding, ridges, point, bevels, edges—*Tang*, its rounding and riveting, three holes for gripe rivets.

HILT. (brass, in one piece)—Cross, knob and pannel of the cross, mortice for the tang, gripe, fillet, necks, swell, knob with an *eagle* on each side, bolster and hole for the tang rivet, grooves and ridges, three holes and bolsters for the gripe rivets—3 *Rivets* (iron.)

SCABBARD, (harness leather, jacked, blackened and varnished,)—*Body*, edges, inner and outer sides—*Mountings* (brass.)—*Ferrule*, stud, bead, cap—*Safes* (buff leather)—4 *Nails* for the ferrule and safes—*Tip*, bead, knob—4 *Nails* for the tip.

Infantry Sword—Model of 1840—Plate 11.

BLADE, (straight, cut and thrust)—Back, edge, groove, bevel, point.

HILT. *Surmounting* (brass,) notch for the hook of the guard, rivet cap, shoulder for the ferrule, hole for the tang; 2 *ferrules*—*Gripe*, wooden body, hole for the tang—*Covering* (sheet brass,) grooves and ridges.

GUARD, in one piece; *branch*, hook and its shoulder; *plate*, flange, bead; *knob*.

SCABBARD (leather)—*Ferrule and hook*, (brass)—*Tip* (brass,) body, front branch, back branch.

This sword is for the non-commissioned officers of foot troops; a similar one, without the guard *plate* and with a blade 26 inches long, for musicians.

The sword for *officers not mounted* is also of the same pattern, with ornamented gilt mountings and a silver gripe; the inner half of the guard plate is made with a *hinge*.

PRINCIPAL DIMENSIONS AND WEIGHTS OF SWORDS AND SABRES.

DIMENSIONS.	Cavalry sabre.	Artillery sabre.	Artillery sword.	Infantry sword.
	In.	In.	In.	In.
Whole length of the sword or sabre				
in its scabbard - - - -	43.25	38.6	26.	38.75
Length of the blade proper - -	36.	32.	19.	32.
Length of the scabbard - - -	37.25	33.	20.	32.5
Width of the blade in the middle -	1.1	1.06	1.8	0.72
Versed sine of the curvature of the blade in the middle - - -	1.5	2.32		
Versed sine of the curvature of the blade in proof - - - -	7.5	6.5	-	6.5
WEIGHTS.				
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Weight of the sword or sabre, com- plete - - - -	4 8	4 1½	3 3	2 5
Weight of the finished blade - -	1 5	-	1 9	
Weight of the scabbard - - -	2 2	-	10	

PROOF AND INSPECTION OF SWORDS AND SABRES.

1st. The dimensions and form of the *blade* are verified by comparing it with the model and by applying the appropriate gauges and patterns, for the length, width and thickness at several points, and the curvature, if any.

2d. The *blade* is then proved as follows:—1st. The point is confined by a staple and the blade is bent on each of the flat sides over a cylindrical block, the curvature of which is that of a circle 35 inches diameter, the curvature of the part next the tang being reduced by inserting a wedge 0.7 inch thick at the head and 14 inches long. 2d. It is struck twice, on each of the flat sides, on a block of oak wood the curvature of which is the same as the above. 3d. It is struck twice on the edge and twice on the back across an oak block 1 foot in diameter. 4th. The point is placed on the floor and the blade bent until it describes an arc having the versed sine indicated in the above table. After these trials the blade is examined to see that it is free from flaws, cracks, or other imperfections, and that it is not *set*, that is to say, does not remain bent.

The blade of the *Artillery sword* is proved by striking each of the sides and edges twice on a flat block of hard oak wood.

The stamp of approval or condemnation is placed on the side of the blade, below the tang.

3d. The form, dimensions and workmanship of the *mountings* are examined

and compared with the model. After the blade is mounted, the sword is again examined and it is struck 4 times on a hard block of wood to test the strength of the mountings. The quality of the brass mountings may be tested by breaking a certain number, not more than 4 in each hundred, which should be taken from the pieces rejected for erroneous dimensions.

4th. The form, workmanship and finish of the *scabbards* are examined and compared with the model, and their fitting to the blades tested. The sewing of leather scabbards and the fastening of the ferrules and tips will be particularly examined.

Steel scabbards are proved by letting fall on them, from a height of 18 inches, an iron weight of two pounds, 1 inch square at the base: 1st, on one side just above the upper band; 2d, on the same side, 6 inches from the tip; 3d, on the opposite side just above the lower band. In this proof the scabbard should not remain indented. The nature of the material (whether iron or steel) may be tested, if there is any doubt, by using nitric acid which will leave a black spot on the steel but not on the iron.

PACKING SWORDS AND SABRES.

Packing boxes for swords and sabres are made on the same principles as those for muskets and other small arms, being furnished with packing boards or partitions made with grooves to receive the scabbards near the hilt and near the point; the swords are placed in their scabbards, with the hilts and points alternately towards each end of the box; except the Artillery swords, two of which are placed in the length of the box, their points resting on a packing board in the middle. Number packed in a box:

30 Cavalry sabres. 50 Artillery swords.

50 Artillery sabres. 50 Infantry swords.

CLEANING SWORDS AND SABRES.

The iron and brass parts of swords and sabres are cleaned in the same manner as those of muskets. When the oil on the blade of a sword is dried up, it will leave a spot which may be removed by covering it with oil and rubbing it smartly, after a short time, with a linen rag. When a leather scabbard has become wet, draw the blade and dry the scabbard slowly without heating it; wipe the blade dry and pass an oiled rag over it and the scabbard, before returning the blade. Oil the blades of arms in store, and also the scabbards, especially on the seams.

CHAPTER SEVENTH.

ACCOUTREMENTS.

NOMENCLATURE, DIMENSIONS.

Cavalry Accoutrements.

SABRE BELT, buff leather—*Waist belt*, 2 inches wide; 36 in. to 40 in. long—1 *square loop* and 2 *D rings* (brass,) for attaching the slings and shoulder strap—1 *belt plate*, brass, oval, 3.6 in. long, 2.2 in. wide, lettered *U. S.*—1 *shoulder strap*, $\frac{1}{8}$ in. wide, 41 in. long, with 2 *hooks*, brass—2 *sabre slings* $\frac{1}{8}$ in. wide; front sling 17 in. long, rear sling 34 in.—4 *studs* for do., brass—1 *sabre hook*, brass wire.

SWORD KNOT, buff leather—*Strap* 1 in. wide, 36 in. long; one end of the strap is fastened to a *tassel* 3 in. long; the other end is passed through the tassel after going round the guard of the sabre, and is fastened by one of the tags of the tassel—1 *sliding loop*.

CARBINE CARTRIDGE BOX, light bridle leather, black—Exterior length 7 in., width 1.3 in., height in front 5 in.—*inner cover* 4 in. wide—*flap* 7.5 in. deep, 8.5 in. wide at bottom, 8 in. at top where it is connected with the box—*pocket* for implements—*strap* 1 in. wide—*button*, brass, on the bottom of the box—*lining*, tin, edges turned over; 2 *lower divisions*, each 2.6 in. deep and 3.4 in. wide, to contain a bundle of 10 cartridges, (musket calibre;) 5 *upper divisions*, each 1.35 in. square, to contain 4 cartridges—*plate*, brass, oval, 2.8 in. long, 1.6 in. wide, lettered *U. S.*

PISTOL CARTRIDGE BOX, similar to the carbine box: Length 6.2 in., width 1.3 in., height in front 3.5 in.—*inner cover*, 3.5 in. wide—*flap*, 6.6 in. wide at top, 6.8 in. wide at bottom, 6 in. deep—*tin*: 2 *lower divisions*, each 2 in. deep and 2.9 in. wide, to contain a bundle of 10 cartridges; 5 *upper divisions*, each 1.2 in. square, to contain 4 cartridges, (rifle calibre)—*plate*, same as for carbine box.

CARBINE SLING, buff leather. Length 56 in., width 2.5 in.—1 *buckle* and 1 *tip*, brass—*swivel* and *D* with *roller*, iron, bright, 2.62 in. wide—*link* and *hook*, iron—*guard-spring*, steel.

CARBINE BUCKET, sole leather, black: Diameter 1.5 in., length of front part 6 in., back part 7.5 in.—*strap*, heavy bridle leather, black, 1 in. wide, 22.5 in. long, clear of the bucket; the strap passes round the sides and bottom of the bucket.

HOLSTERS. *Pipe*, sole leather, black: diameter of cylindrical part 2 in., length of do. 7.5 in.; width of the mouth, 4.7 in.; depth, 2.5 in.; whole length, 14.5 in.—*pocket*, light upper leather, 3.2 in. long, 2.5 in. deep, lined with *tin*—5 *cylindrical divisions*, diameter 0.6 in., each for one cartridge—1 *centre piece* to connect the two holsters, light bridle leather, black; mean length about 8 in., width 5.25 in.—2 *straps* 14 in. long, 0.6 wide, with 2 buckles, to attach the holsters to the saddle—2 *surcingle loops*, light bridle leather, black, 1.5 in. wide, 3.5 in. long, doubled.

HOLSTER COVERS, black leather; 23 in. long, 9.5 in. wide over the cartridge pocket, 7.5 in. in the middle—*straps*, 6 in. long, 1 in. wide, to button on the holster.

Horse Equipments for Dragoons—Pattern of 1841.

The *leather parts* are made of strong black leather, unless otherwise specified. The *buckles* and *rings* are made of wrought iron tinned, and all the buckles have *rollers*.

NOTE. For an explanation of some technical terms, see *Page 84*.

Halter.

The *nose band*—2 *chin straps*; 1 *loop* for ditto—the *throat strap*—2 *cheek straps*, forming also the throat lash; 1 *buckle* and 2 *loops* for ditto—1 *loop* with a button hole, which serves to fasten the halter to the crown piece of the bridle—all these pieces are 1 in. wide; they are connected together by 2 *square cheek loops*, (iron,) the lower sides of which are covered with leather, and by 2 *throat strap rings*—the *shank*, (or *hitching strap*,) 1 in. wide, with 1 *buckle* and 1 *loop*—1 *billet* sewed to the shank, to connect it with the lower throat strap ring.

Snaffle Bridle.

HEAD STALL: The *long cheek* on the off side, the *short cheek* on the near side, $\frac{3}{4}$ in. wide—1 *buckle* and 1 *loop* for ditto—the *brow band* made with two loops through which the cheek straps pass.

SNAFFLE BIT, (wrought iron, burnished,) 2 *mouth pieces* connected by eyes; the outer ends pierced with holes for 2 *rings*.

REIN, $\frac{3}{4}$ in. wide—1 *buckle* and 2 *loops*.

Curb Bridle.

Crown piece 2 in. wide, split at each end into two equal parts, to fit 2 *billets* on the near side and 1 *billet* and 1 *throat lash* on the off side—1 *buckle* and 2 *loops* for the throat lash—3 *loops* for the *spare curb chain*; the loop on the top of the crown has a *button* for attaching the button-hole strap on the halter—the *brow band*, 1½ in. wide, with 2 *loops* at each end for the *billets* of the crown piece—2 *brass plates*, for marking and numbering the bridle—2 *cheek straps*, each with 1 *buckle* and 1 *loop* at the upper end, and 1 *buckle* and 2 *loops* at the lower end—2 *bit billets*, sewed to the under side of the cheek straps—the *nose band*, 1 in. wide in rear, passing through openings between the cheek straps and bit billets; 1 *buckle* and 1 *loop* for ditto.

BIT, wrought iron, burnished: 2 *cheeks*, the upper part straight, with an eye for the bit billet and another for the curb chain; the lower part an *S*, with an eye for the *bridle ring*—the *mouth piece* dovetailed and riveted to the cheeks; the *port mouth*—the *bar*, riveted to the lower ends of the cheeks—the *curb chain*, (tinned iron,) fastened by a *hook* to the off cheek and by an *S* to the near cheek—2 *scutcheons* (brass,) riveted to the cheeks.

The bits are made of three sizes and of three varieties in the form of the port-mouth and the degree of severity. In a large number, one-sixth are *mild*, one-sixth *severe*, the rest *medium*. One fifth of each kind are 4.625 in. wide between the cheeks, three-fifths are 4.875 in. wide, and one-fifth are 5.125 in. wide.

REINS, 1 in. wide, made of one piece of leather split in two—2 *bit billets* with 2 *buckles* and 2 *loops*; 1 *sliding loop* and 1 *button*—the *whip*, of braided leather.

Saddle.

WOODEN PARTS, (beech or maple.) The *pommel*—the *cantle*—2 *side bars*: The pommel and cantle are dovetailed into the side bars, fastened by wooden *pins* and glued. The trees are of two sizes, 12 in. and 13 in. wide between the lower ends of the pommel.

IRON PARTS. The *pommel plate*, fastened to the front of the pommel by 6 *screws* and 2 *rivets*—2 *pommel squares*, each fastened to the side bar by 3 *rivets*—the *cantle plate*, fastened to the rear of the cantle by 6 *screws* and 2 *rivets*—2 *cantle squares*, each fastened to the side bar and to the rear of the cantle by 6 *rivets*—2 *stirrup-bar plates*, each fastened to the side bar and to the pommel by 4 *screws*—2 *valise staples*, riveted over 2 *burrs* on the front of the cantle—*cantle moulding* (sheet brass,) fastened to the cantle with small *nails*.

LEATHER PARTS. The thongs used for connecting the parts together are made of strong raw hide or alum dressed skin.

The seat, (or *straining*,) raw hide, alum dressed, *nailed* to the pommel and cantle and laced to the side bars with *thongs*.

The pad, covered with russet sheep skin, lined with strong canvass, stuffed with curled hair, and quilted; it is attached to the tree by 4 *strings* and 4 *loops* passing over the pommel, the cantle, the girth and the girth billet.

The girth $2\frac{3}{4}$ in. wide, attached with a *thong* to the off side bar of the tree—1 *buckle* and 2 *loops* for do. the *girth billet*, made double by means of a *layer* 2 in. wide, and attached, in the same manner as the girth, to the near side bar.

2 *Chapes*, with 2 *buckles* and 2 *loops* for the crupper straps, fastened to the points of the side bars with *thongs*.

STIRRUPS, of wrought iron, japanned black; the *bar*, double and roughed on the upper side; the *sides*; the *eye* for the stirrup leather—2 *stirrup leathers* $1\frac{1}{4}$ in. wide, stitched double for a length of 10 in. from the buckle, the stirrup resting on the double part—2 *buckles* and 4 *loops* for do. The stirrup leather passes over the stirrup bar through a mortice in the side bar.

CRUPPER. The *dock* stuffed with wool or paper—the *body* 2 inches wide, split into 2 *straps* 1 inch wide, to which the dock is sewed, and into 2 *billets* 1 inch wide, by which the crupper is attached to the saddle.

BREAST PLATE, 1 inch wide, with a *buckle* at the lower end to form a loop for the girth; at the upper end a *heart* covered with a *brass plate*—2 *stays* $\frac{7}{8}$ in. wide, sewed to the upper end of the breast plate; 2 *buckles* and 4 *loops* for do.—1 *breast plate strap* $\frac{7}{8}$ in. wide; it passes through 2 mortices in the connecting strap and under the band on the pipe of the holster and the loop on the holster bag, and is buckled to the stays.

HOLSTER: black leather, jacked and varnished; the mouth is stiffened with iron wire covered with leather—a *band* round the pipe, passing through a *loop* in a *strap* attached to the connecting strap.

HOLSTER BAG, for combs, brushes, &c.; *mouth strap* passing through 2 *loops* sewed on the bag—1 *buckle* and 1 *loop* for do.—1 *loop* for the bag strap.

CONNECTING STRAP, to which the holster and bag are fastened by *thongs*; it is doubled and stitched, with an opening in the centre through which the head of the pommel passes. The strap is fastened to the pommel with 2 *thongs*; the holster being on the near side and the bag on the off side.

STRAPS, $\frac{7}{8}$ in. wide. 1 *Holster strap* and 1 *bag strap*, passing round the lower ends of the holster and the bag, through the loops made for that purpose; used

to strap up the cloak, &c. ; each strap has 1 *buckle* and 2 *loops*—1 *middle cloak strap*, passing through a loop made with a thong in the head of the pommel—1 *buckle* and 2 *loops* for do.—2 *double cloak straps*, each with 2 *buckles* and 2 *loops* : these straps pass round the holster and bag, under the thongs which attach the connecting strap to the saddle tree ; each strap has but one *billet* which is buckled first over the cloak and then over the schabraque, one of the buckle straps being passed through a slit made in the schabraque for that purpose.

1 *Middle valise strap* ; 1 *buckle* and 2 *loops* for do.—2 *double valise straps*, each with 2 *buckles* and 3 *loops* : these straps pass through the valise staples and through slits in the schabraque ; they are buckled first over the valise and then over any light package that may be carried on the valise.

TWO SHOE POCKETS, attached to the rear of the side bars of the tree with the same thongs that hold the chapes for the crupper buckles.

CARBINE BUCKET, sole leather, jacked like the holster ; it is made of two pieces, with a *band* sewed round the mouth and a mortice in the lower part—the *bucket strap* 1 inch wide, with 1 *buckle* and 2 *loops* : it passes through the mortice and through 2 loops in the band of the bucket, and is attached to the saddle by passing under a *thong* tied to the connecting strap and to the lacing of the seat.

CARBINE STRAP, $\frac{7}{8}$ in. wide ; 1 *buckle* and 2 *loops* for do : it passes through a loop in the thong that holds the connecting strap of the holster and bag, on the off side.

BLANKET, wool, dyed brown, 54 inches square, weighing not less than $3\frac{1}{4}$ lbs.

SCHABRAQUE, dark blue cloth, trimmed with the color of the facings of the corps, lined with strong canvass ; the *seat*, white sheepskin dressed with the wool on ; the skirts are faced with leather in the middle and lined with leather at the flanks—The schabraque is pierced with several *slits* for the passage of the straps of the saddle ; it is secured to the saddle in front by the two double cloak straps, in rear by the two double valise straps, and in the centre by the surcingle.

SURCINGLE, leather $2\frac{3}{4}$ in. wide ; it has at one end a *chape*, with a buckle and 3 loops ; at the other end, a *billet* $1\frac{3}{8}$ in. wide.

VALISE, dark blue cloth, trimmed like the schabraque ; diameter inside 6 in., length 21 in. ; the ends stiffened with plates of leather—it is *lined* with strong canvass and closed, under the flap, with *lacings* of strong twine—3 *straps*, with *buckles* and *loops*, and 3 *billets* are sewed to the outside of the valise.

SPURS, wrought iron, japanned black: the *plate* attached to the heel of the boot by a *point* behind and 2 *screws* at the sides—the *shank*—the *rowel*, (steel.)

Infantry Accoutrements.

CARTRIDGE BOX, bridle leather, black; 7.7 in. long, 1.6 in. wide, 5.8 in. deep; in front—*inner cover*, light upper leather, 4 in. wide—flap 8.5 in. at bottom and 8 in. at top, with *strap*—*brass button*, on the bottom of the box—*pocket* for implements, light upper leather, 6 in. long, 3.5 in. deep, with *flap*—*strap* and *loop* for do—2 *roller buckles* for belts, on bottom of box—2 *tins*, each with one *lower division* 3 in. by 3.3 in., to contain a bundle of 10 cartridges, and 2 *upper divisions*, 1 of 2 in. by 1.35 in. to contain 6 cartridges, 1 of 1.35 in. square, to contain 4 cartridges; depth of each division 2.7 in.—*plate*, brass, oval, 3.5 in. by 2.2 in. lettered U. S. The edges of the tin lining are turned over.

CARTRIDGE BOX BELT, buff leather; 2.25 in. wide, 55.5 in. long clear of the 2 *billets*, 4.25 in. long and 0.875 in. wide, for the buckles.

BAYONET SCABBARD, light bridle leather, black; 1.1 in. wide at top, 17 in. long including ferrule and tip—*upper band*, brass, 2.5 in. long—*ferrule* and *tip*, brass, 3.1 in. long.

BAYONET BELT, buff leather, 2.3 in. wide; *short branch* 16.25 in. long; *long branch* 37 in., with a loop—*frog*, 2.5 in. deep—*plate*, brass, circular, 2.5 in. diameter, with an *Eagle*—The frog of the non-commissioned officer's belt is made double, to receive the sword scabbard.

Note. The bayonet belt is about to be discontinued; the bayonet scabbard will be attached to a frog sliding on the waist belt.

WAIST BELT, buff leather; 1.5 in. wide, 38.5 inch long, with a *loop* at one end—*plate*, brass, the same as for carbine cartridge box.

GUN SLING, bag leather, 1.25 in. wide, 44 in. long with a standing and a sliding *loop*—*hook*, brass.

BRUSH AND PICK. *Brush*, Russia bristles, 6 in. long, doubled—*socket*, sheet brass, 0.45 in. diameter, 1.4 long. *Pick*, iron or brass wire, 3.75 in. long—*Chain*, brass wire; 2 *links*, each 3.75 in. long; *wrapping*, brass wire; 2 *branches* for brush and pick of 2 links each, each link 3 in. long.

Artillery Accoutrements.

SABRE BELT for mounted artillery; buff leather, 1.7 in. wide, 36 to 40 in. long—2 *leather loops*, sewed on the outside of the belt for attaching 2 *brass loops* for the slings—2 *sabre slings*, like those on the cavalry sabre belt—4 *studs* for do.—1 *sabre hook*—1 *belt plate*, brass, circular, 1.4 in. diameter, lettered U. S.;

it slides on the belt and is fastened by a *brass hook* and a *sliding loop*—the plate hooks in a *ring* 1.95 in. exterior diameter, attached to the left side of the belt.

SWORD KNOT. Like that for cavalry.

SWORD BELT for foot artillery; buff leather, 1.7 in. wide, made in three pieces; *long branch* 24 in.; *frog piece* 4.5 in.; *short branch* 4 in.; they are united together by 2 *loops*, brass—*frog*, 3.5 in. deep, 2.5 in. wide at top and 2.3 in. at bottom, suspended to the loops by 2 *slings* 1.3 in. wide and 3.5 in. long—*Plate*, the same as for the artillery sabre belt.

This belt is also used by the non-commissioned officers of infantry, when armed with the artillery sword.

Rifle Accoutrements.

POUCH, light upper shoe leather, 7 in. wide at bottom, 6.6 in. at top, 5.5 in. deep, made with *gussets* at the sides and bottom—*partition*, buff leather—*flap*, 2.7 in. deep, with a *strap* and leather *button* on the front side—2 *loops*, japaned iron, 0.9 in. wide and 0.7 in. long, for the belt rings.

FLASK. *Body* (copper bronzed,) length 7 in., greatest width 4.9 in., thickness 2 in.; diameter at top 1.7—*inner charging tube*, (brass) 0.57 in. diameter, 1 in. long—*outer charging tube* 0.65 in. diameter, 1.9 in. long—*valve and spring*—2 *rings* for belt, (copper.)—Flask holds 8 oz. of powder: maximum charger 100 grains, minimum 85 grains—Weight of flask complete 13 oz.

FLASK-AND-POUCH BELT, buff leather, 1.45 in. wide—*belt*, 26 in. long—2 *straps* at each end, 13.5 in. long, 0.6 in. and 0.85 in. wide, to which the pouch and flask are attached by *brass hooks*.

WAIST BELT AND PLATE.

BAYONET SCABBARD.

BAYONET BELT AND PLATE.

GUN SLING.

BRUSH AND PICK.

The same as for the Infantry; except the *bayonet belt* for Hall's rifle, which is 1.5 in. wide, with a frog 2.25 in. deep.

MATERIALS REQUIRED FOR ACCOUTREMENTS.

Leather.

- 19 Infantry cartridge box belts
- 25 Infantry bayonet belts
- 45 Infantry waist belts
- 33 Rifle pouch-and-flask belts
- 33 Rifle bayonet belts
- 17 Cavalry sabre belts
- 20 Artillery sword belts
- 17 Carbine slings

Can be cut out of one hide of buff leather.

40 Gun slings—out of one butt of *bag leather*.

8 Pairs of holsters }
40 Carbine buckets } Out of 1 side of *heavy sole leather*.

11 Infantry cartridge boxes—except }
pockets and inner covers } Out of 1 side of *heavy bridle leather*.

50 Carbine bucket straps

30 Bayonet scabbards

10 Carbine cartridge boxes

12 Pistol cartridge boxes (except ends)

20 Holster centre pieces

60 Pairs of holster straps

70 Surcingle loops

12 Rifle pouches

50 Pockets for Infantry cartridge }
boxes } Out of 1 side of *light upper shoe leather*.

50 Inner covers for do.

Thread.

100 Infantry cartridge boxes, 1.25 lbs.

100 Carbine do. 1.0 "

100 Pistol do. 0.9 "

100 Holsters 1.25 "

100 Rifle pouches 0.75 "

100 Gun slings 0.13 "

100 Infantry bayonet belts 0.4 "

100 Infantry waist belts 0.06 "

100 Artillery sword belts 0.8 "

100 Sabre belts 0.33 "

100 Rifle bayonet belts 0.25 "

100 Rifle pouch belts 0.13 "

Shoe thread, green, No. 10, waxed
with rosin wax.

Shoe thread, No. 3, half bleached,
waxed with beeswax.

Metals.

For 100 sets of Cavalry sabre belt mountings.

100 Sabre hooks,	-	-	-	2.5 lbs. brass wire, No. 10.
100 Loops,	-	-	-	4 lbs. brass wire, No. 10.
100 Large hooks,	-	-	-	4 lbs. sheet brass, No. 11.
100 Small hooks,	-	-	-	1.5 lb. sheet brass, No. 14.
200 Rings,	-	-	-	4 lbs. brass wire, No. 10.
400 Rivets,	-	-	-	0.375 lb. brass wire, No. 15.
400 Studs,	-	-	-	cast brass.
100 Belt plates,	-	-	-	See next page.

Tins for 100 carbine cartridge boxes.

75 sheets of single tin.

1 lb. tinner's solder, (2 tin to 1 lead.)

Tins for 100 pistol cartridge boxes.

48 sheets of single tin.

1 lb. solder.

Tins for 100 pairs of holsters.

4½ sheets of single tin.

1 lb. solder.

} These tins may be cut from the remnants of
the sheets required for 100 infantry cartridge
boxes.

Tins for 100 Infantry cartridge boxes,

125 sheets of single tin.

1 lb. tinner's solder.

For 100 plates for Infantry cartridge boxes and Cavalry sabre belts.

4 lbs. sheet brass, No. 26.

0.625 lbs. iron wire, No. 14.

4 lbs. soft solder, (1 tin to 2 lead.)

For 100 sets of bayonet scabbard mountings.

10 lbs. sheet brass, No. 24.

4.7 lbs. brass wire, 0.45 in. thick.

0.14 lbs. copper wire, No. 15.

0.2 lbs. spelter.

For 100 Infantry bayonet belt plates.

3.75 lbs. sheet brass, No. 26.

0.844 lb. iron wire, No. 14.

4 lbs. soft solder.

For 100 plates for Infantry waist belts and for carbine and pistol cartridge boxes.

3 lbs. sheet brass, No. 26.

0.75 lb. iron wire, No. 14.

3 lbs. soft solder.

For 100 gun sling hooks and rivets,

1.5 lb. sheet brass, No. 14.

0.16 lb. brass wire, No. 15.

For 100 brushes and picks.

2.5 lbs. sheet brass, No. 23.

4 lbs. brass wire, No. 15.

2.75 lbs. brass wire, No. 20.

0.5 lb. iron or brass wire, No. 16.

1.31 lb. Russia bristles, 6 in. long.

For 100 Artillery sword belts.

200 loops, - - - 8.5 lbs. brass wire, No. 10.
 100 small hooks, - - - 1.5 lb. sheet brass, No. 14.
 200 rivets, - - - 0.14-lb. brass wire, No. 15.

For 100 Artillery sabre and sword belt plates.

25 lbs. pig brass.

For 100 Rifle pouch-and flask belts.

4 lbs. sheet brass, No. 15.
 0.66 lb. brass wire, No. 15.

WEIGHT OF ACCOUTREMENTS.

	lbs.
100 Cavalry sabre belts and plates,	115
100 Carbine cartridge boxes and plates,	118
100 Pistol do do	81
100 Carbine slings and swivels,	110
100 Carbine buckets,	28
100 Pairs of holsters,	150
100 Holster covers,	63
100 Infantry cartridge boxes complete,	176
100 Cartridge box belts,	37
100 Bayonet scabbards,	20
100 Bayonet belts and plates,	53
100 Waist belts and plates,	26
100 Gun slings,	15
100 Brushes and picks,	11
100 Artillery sword belts and plates,	73
100 Rifle pouches,	43
100 Rifle flasks,	81
100 Rifle flask-and-pouch belts,	27
100 Rifle bayonet belts and plates,	44

CHAPTER EIGHTH.

GUNPOWDER.

MATERIALS.

Saltpetre.

Saltpetre, nitre, nitrate of potassa, is composed of 53.45 nitric acid and 46.55 potassa—its specific gravity is 2,090—it melts at 660° and is decomposed at a red heat—100 parts of water, at the temperature of 32° , dissolve 13.32 parts of nitre; at 59° , 25.49; at 86° , 45.90; at 104° , 63.80; at 140° , 110.70; at 176° , 170.80; at 212° , 246.15. Saltpetre crystallizes generally in six-sided prisms terminated by six-sided pyramids, or in needles deeply striated—its taste is cool, saline, and slightly bitter—when thrown on burning charcoal it melts and deflagrates violently.

Saltpetre occurs naturally in great quantities, on the surface of the earth in India and other warm countries, and in the limestone caves of Virginia, Georgia, Tennessee and Kentucky; in the last named State, it is also found in the form of what is termed *rock ore*, being sand stone containing a very large proportion of nitre. This salt is formed spontaneously by the decomposition of animal and vegetable substances in moist situations, and on this principle artificial nitre beds are made for its production. Saltpetre obtained from any of these sources may be separated from the greater part of the foreign salts and earthy matter by lixiviation with wood ashes and evaporation; the nitrous earth of India yields about one-fifth of its weight of nitre; that of the nitre caves, from one to ten pounds of nitre to the bushel, and the rock ore as much as 20 or 30 pounds to the bushel. The best artificial nitre beds afford annually about a quarter of a pound of nitre to a bushel of earth. Nearly all the saltpetre used in the United States, for the manufacture of gunpowder, is obtained from India, whence it is imported in a crystallized state, called *grough saltpetre*, containing generally from 6 to 12 per cent. of foreign salts, earths, and water.

TEST OF GROUGH SALTPETRE: To a pound of grough saltpetre add a pint of water saturated with pure saltpetre; stir the mixture for ten minutes with a glass rod and decant the liquor on a filter; wash the saltpetre a second time in the same manner, with half a pint of the saturated solution, and pour the whole on the filter; let it drain and then dry it perfectly by placing it first on a bed of some absorbent matter, such as ashes or lime, and then by evaporation in a

glass vessel over a gentle fire. The saturated solution having taken up only the foreign salts, what remains on the filter, (allowing 2 per cent. for earthy matter and the saltpetre left by the saturated water,) is the quantity of pure saltpetre contained in the pound of grough. As the changes of temperature during the operation may affect the quantity of pure saltpetre remaining on the filter, it is proper to perform a corresponding operation, at the same time and under the same circumstances, on a like quantity of pure saltpetre; the gain or loss thus ascertained will show the correction to be made in the former result.

Refining Saltpetre.

Saltpetre to be used in the manufacture of gunpowder requires to be freed from the impurities present in its rough state; this may be done by boiling it in pure water and filtering the liquor through canvass bags. The method of refining on a large scale, at the refinery of Paris, is as follows:

FIRST WASHING. This first operation is performed on 11,660 lbs. of grough saltpetre, containing about 6 per cent. of foreign salts and 6 per cent. of water and earthy matters. This is washed with 4,400 lbs. of water saturated with pure saltpetre, obtained in previous operations; if that is not at hand pure water may be used: stir it well, and at the end of 12 hours rake up the saltpetre towards one side of the vessel, and let the water run off at the opposite side, carrying with it the foreign salts; this is afterwards treated as mother water. After this washing the saltpetre contains only 1 per cent. of foreign matter, and the quantity is reduced to 11,000 lbs.

MELTING. In a boiler of the capacity of about 900 gallons, dissolve 10,000 lbs. of the saltpetre from the first washing in 300 gallons of water, at a moderate heat, putting in first three-fourths of the saltpetre with a proportional quantity of water, and adding the rest in three successive parts. Prepare a solution of 36 oz. of glue in $4\frac{1}{2}$ gallons of water, and when ebullition is about to commence in the boiler, pour in three-fourths of the solution of glue diluted with twice its bulk of water, and skim carefully; then add 22 gallons of water, in order to diminish the density of the liquid and to allow the foreign salts and earthy matters to pass through it and settle at the bottom, or to rise in scum; this is called *a washing*. Throw into the boiler one-third of the remainder of the saltpetre and the rest of the glue diluted with four gallons of water; skim for about one hour—make a second washing, and about two hours after, a third—continue the skimming and evaporation, increasing the heat, until there remains in the boiler but one part of water to four of saltpetre—let the liquor stand for some hours, keeping up a sufficient heat to prevent crystallization, and then draw it off into the crystallizing vat.

CRYSTALLIZATION. The liquor is kept in constant agitation by means of rakes, to prevent the formation of large crystals; draw off the mother water when its temperature is reduced to 104° , and let the saltpetre drain for some hours.

WATERING. When taken from the crystallizer the saltpetre contains not more than 1-500th of foreign salts; it is put into boxes capable of containing about 4,800 lbs.; on each of these boxes pour, with watering pots, 220 gallons of water, one-third at a time—the two first waterings are allowed to remain on the saltpetre two hours before being drawn off through openings in the bottom of the box; the third merely passes through the saltpetre.

DRYING. After these waterings the saltpetre contains but 1-18000th of hydrochlorates. It is left to drain several days, and then dried in drying vats at a low heat, being constantly stirred.

PACKING. If designed for transportation, the saltpetre when thoroughly dried, being then perfectly white and in small grains, is passed through a sieve of fine wire gauze and packed in barrels, which may be afterwards used for gunpowder. A 100 lbs. powder cask will hold about 132 lbs. of saltpetre.

The mother water, as it issues from the crystallizer, is received in basins where it cools and deposits saltpetre, which is added to that which has undergone the first washing in another operation; the rest is evaporated to obtain grough saltpetre.

The water used for watering the refined saltpetre is kept to make the first washing of the grough saltpetre, or else it is added to the mother water.

The scum which is obtained in melting is called *foul scum*; put about 4,400 lbs. of it into a boiler with 265 gallons of water; heat it gradually until it begins to boil; skim and allow it to settle; then draw off the liquor which, in cooling, will deposite grough saltpetre. On the residuum, whilst still hot, pour about 250 gallons of water and add the *second scum*, so as to fill the boiler; after this has been boiled, skimmed and allowed to settle, draw off the clear liquor and add it to the mother water. Add the last scum and the dregs to the materials for lixiviation.

Thus, 11,660 lbs. of grough saltpetre furnish 8,000 lbs. of pure, dry saltpetre, besides 200 lbs. remaining in the scum, 1,200 lbs. in the mother water, and 1,000 lbs. in the washings, which are obtained in the subsequent operations; in all, 10,400 lbs. of pure saltpetre.

TEST OF REFINED SALTPETRE. In order to be used in the manufacture of gunpowder, saltpetre should not contain more than 1-3000th of chlorides.—To test this, dissolve 200 grains of saltpetre in the least possible quantity (say 1000 grains) of tepid distilled water; pour on it 20 grains of a solution of nitrate of silver containing 10 grains of the nitrate to 1033 grains of water, that being the

quantity required to decompose 200-3000ths of a grain of muriate of soda; filter the liquid and divide it into two portions—to one portion, add a few drops of the solution of nitrate of silver; if it remains clear, the saltpetre does not contain more than 1-3000th of muriate of soda—to the other portion, add a small quantity of solution of muriate of soda; if it becomes clouded the saltpetre contains less than 1-3000th. By using the test liquor in very small quantities, the exact proportion of muriate of soda may be ascertained; at the refinery of Paris it does not exceed 1-18000th of the saltpetre, and this degree of purity is attained also at the refinery of Messrs. Dupont. Saltpetre for the best sporting powder is refined a second time and contains not more than 1-60000th part of chlorides.

Charcoal.

Charcoal obtained from light woods is the best for the manufacture of gunpowder, being more easy to pulverize. *Willow* and *poplar* are used for this purpose in the United States.

The wood must be sound, and should not be of more than 3 or 4 years growth, and about 1 inch in diameter; branches larger than that should be split up. It is cut in the spring, when the sap runs freely, and is immediately stripped of its bark. The smaller branches are used for fine sporting powder.

The operation of charring may be performed in pits, but the method now almost universally pursued in making charcoal for gunpowder is that of *distillation*. For this purpose the wood is placed in an iron vessel, generally of a cylindrical form, to which a cover is luted; an opening, with a pipe, is made to convey off the gaseous and liquid products, and the wood is thus exposed to the heat of a furnace.

The charcoal thus obtained should retain a certain degree of elasticity, and should have a *brown* color, the wood not being entirely decomposed; it retains the fibrous appearance of the wood, and the fracture is iridescent. As it readily absorbs 1-20th of its weight of moisture, it should be made only in proportion as it is required for use. Wood contains generally about 52 per cent. of carbon, but distillation furnishes not more than 30 to 40 per cent. of charcoal.

The specific gravity of charcoal triturated under heavy rollers is about 1,380; but in sticks, as it comes from the charring cylinders, it rarely exceeds 300.

Sulphur.

Pure sulphur is of a citron yellow color and shining fracture; it crackles when pressed in the hand. The specific gravity of native sulphur is 2,033; that of sulphur refined by sublimation 1,900; its specific gravity is diminished by tritu-

ration. Sulphur melts at 220° , but at 320° it takes the consistency of paste; it sublimes at 680° . It is insoluble in water, but soluble in oils and in alcohol.

Sulphur is generally found in great quantities in the neighborhood of volcanoes; it may also be obtained from metallic ores (pyrites) and other sources. Most of that used in the United States is obtained from the French refineries.

Crude sulphur, as extracted by the first sublimation from the ore, contains about 8 per cent. of earthy matter. It is purified by a second sublimation from which it is collected in the form of powder, called *flowers of sulphur*, or it is melted and run into moulds, making *roll brimstone*. It may also be refined, but not so thoroughly, by being simply melted and skimmed.

Pure sulphur is entirely consumed in combustion, and its purity is thus easily tested by burning about 100 grains in a glass vessel; the residuum should not exceed a small fraction of a grain.

MANUFACTURE OF GUNPOWDER.

Proportions of Ingredients.

		Saltpetre.	Charcoal.	Sulphur.
	By the Atomic theory	75.4	12.8	11.8
IN THE UNITED STATES:				
	For the military service	76	14	10
		75	15	10
	For sporting	78	12	10
		77	13	10
IN ENGLAND:				
	For the military service	75	15	10
	For sporting	78	14	8
		75	17	8
IN FRANCE:				
	For the military service	75	12.5	12.5
	For sporting	78	12	10
		76	14	10
	For blasting	62	18	20

Fabrication.

This consists essentially in the following operations: *pulverizing the ingredients, incorporation, compression, granulation, and drying.*

POUNDING MILL. In this method of fabrication the first three operations are performed at the same time by the pestles. A mill contains generally 20 or 24 mortars and pestles in two rows; the pestle weighs 90 lbs., and falls 16 inches, fifty-five times in a minute; the lower part of the pestle is made of bronze or of

very hard wood. The mortars are nearly spherical and are dug out of a piece of oak, having a piece of harder wood in the bottom.

Each mortar receives about 20 lbs. of composition. The stamping is continued about 11 hours. The proper charge of charcoal in small pieces is first put in, with a quantity of water equal to one-tenth of the weight of composition, say 1 quart; after this has been pounded half an hour, at the rate of 40 strokes a minute, add the saltpetre and then the sulphur, previously pulverized in a mill or rolling barrel and sifted. Mix the materials with the hand, and for the first quarter of an hour let the stamping continue at 40 strokes a minute; at the end of each hour the composition is passed from each mortar into the next—at the 6th or 8th *change*, add half a pint of water. During the last two hours no change is made, in order that the composition may form into cake. When taken from the mortar it is dried, so as to reduce the contained moisture to about 4 per cent.; it is then grained.

ROLLING BARRELS. In order to lessen the duration and danger of pounding in the mortars, the materials may be pulverized and mixed in rolling barrels, before being put under the pestles.

These rolling barrels are about 44 in. diameter and 22 in. long on the interior; they are made of strong leather or hides stretched over a frame the slats of which project inwardly about 0.5 in. and are 9 in. apart; the elasticity of the leather prevents the composition from adhering to the sides, which it would do in wooden barrels. Each barrel contains 100 lbs. of balls about 0.25 in. diameter, made of zinc or of an alloy of 75 copper and 25 tin; the barrel revolves 25 or 30 times in a minute. The charge of composition is half the weight of the balls.

For the purpose of pulverizing, the charcoal and sulphur are rolled together for two hours. For incorporation, the saltpetre is added in the state in which it comes from the refinery, and the mixture is rolled two hours more; it is then placed under the pestles, adding 10 per cent. of water, and it is beaten for 3 hours only.

PRESS. Instead of being put in the pounding mill the composition from the rolling barrels may be spread in thin layers, moistened with 10 per cent. of water distributed very equally with a fine watering pot or a brush, and subjected to pressure by a hydraulic or screw press, by which means it is brought to the state of a cake. The composition in some manufactories is subjected to the press after being incorporated in the pounding mill.

CYLINDER MILLS. These mills, first used in England and now generally adopted in the manufacture of gunpowder, supply the place of pounding mills in performing at the same time the operations of pulverizing, incorporating and pressing the composition. They consist of two cylinders of marble or cast iron,

weighing about 5 tons each, rolling in a circular trough of the same material, the inner diameter of which is about three feet; a wooden plough follows the cylinders, to bring the powder towards the centre of the trough. The cylinders revolve 10 times in a minute, and run from 1 to 3 hours on each charge of 50 lbs. of composition.

GRANULATION. The composition being formed into *cake*, by any of the above methods, the next process is to break it up into grains; to facilitate this, it is aired or partially dried; it is then put into a graining sieve formed of parchment pierced with holes, where it is broken up by the action of a lenticular disc of hard wood, weighing about 5 lbs., being 8.5 in. in diameter, 2.75 in. thick in the middle, 2 in. at the edge; the workman shakes the sieve in such a manner that the disc may move round it against the border, and the grains pass through the holes as fast as they are sufficiently reduced. Another method of graining is to pass the cake between wooden rollers. The grains thus formed are sifted, to separate those which are too coarse or too fine, and also to separate from each other the different kinds of grains for *cannon*, *musket* and *rifle* powder.

Diameter of the holes in the sieve for	Cannon powder	{	Maximum	0.100 in.
		{	Minimum	0.070 in.
	Musket - -	{	Maximum	0.070 in.
		{	Minimum	0.050 in.
	Rifle - -	{	Maximum	0.035 in.
		{	Minimum	0.025 in.

GLAZING, is necessary in order to enable gunpowder to resist the effects of shaking in transportation, and of exposure to the moisture of the air. All the powder made for the Ordnance Department is glazed. This operation is performed by enclosing the powder, containing about 3 per cent. of moisture, in a large glazing barrel which makes 15 or 20 revolutions in a minute; a charge of 500 lbs. is thus treated for about 24 hours or less, according to the effect required.

DRYING. Gunpowder is dried in two ways—1st, in the open air; the powder is spread upon sheets laid on tables placed in a suitable situation where it remains 10 or 12 hours, being frequently stirred to expose it thoroughly to the sun: in summer, it requires to be sometimes covered in the heat of the day, to prevent the loss of the sulphur—2dly, in a drying house, where the powder is exposed in layers from 1 in. to 4 in. thick, to a current of air heated to about 140°, by means of a furnace or by hot water pipes.

DUSTING. After powder has been glazed and dried it is sifted in fine sieves, or through bolting cloths, in order to clean it thoroughly, and to cool it before being barrelled. The dust and small grains obtained in this and previous operations are again pressed or worked over to make inferior powder, or mixed with a portion of fresh composition in the mills.

ROUND POWDER may be made in an expeditious manner as follows: Fix a powder barrel on a shaft passing through its two heads, the barrel having ledges on the inside; to prevent leakage, cover it with close canvass glued on, and put the hoops over the canvass. Put into the barrel 10 lbs. of sulphur in lumps and 10 lbs of charcoal, with 60 lbs. of zinc balls, or of small shot, (down to No. 4, 0.014 in. in diameter nearly;) turn it, by hand or otherwise, 30 revolutions in a minute; to 10 lbs. of this mixture thus pulverized add 30 lbs. of saltpetre, and work it two hours with the balls; water the 40 lbs. of composition with 2 quarts of water, mixing it equally with the hands; granulate with the graining sieve. The grains thus made, not being pressed, are too soft. To make them harder, put them into a barrel having 5 or 6 ledges projecting about 0.4 in. inside; give it at first 8 revolutions in a minute, increasing gradually to 20. The compression will be proportionate to the charge in the barrel which should not, however, be more than half full; continue this operation until the density is such that a cubic foot of the powder shall weigh 855 oz., the mean density of round powder: strike on the staves of the barrel from time to time to prevent the adhesion of the powder.

Sift the grains and dry the powder as usual; that which is too fine or too coarse is returned to the pulverizing barrel.

This powder is round and the grain is sufficiently hard on the surface, but the interior is soft, which makes it unfit for keeping and may cause it to burn slowly. This defect may be remedied by making the grains at first very small, and by rolling them on a sheet or in a barrel, watering them from time to time, and adding the pulverized composition in small portions; in this way, the grains will be formed by successive layers; they are then separated according to size, glazed and dried.

It appears from experiments that the simple mixture of the materials makes a powder which gives nearly as high ranges with the cannon as grained powder; the incorporated dust from the rolling barrel may therefore be used in case of necessity.

DENSITY OF GUNPOWDER.

The density of gunpowder may be approximatively determined by taking the weight of a given quantity; this is called the *gravimetric density*, and the measure used for the purpose, a *gravimeter*; the gravimetric density may be expressed by the weight of a cubic foot in ounces, and a convenient form for the gravimeter is a brass cylindrical measure, 4 inches in diameter and 5.093 inches in height, containing 64 cubic inches, or 1-27th of a cubic foot. The weight of the

contents should be ascertained with the powder loose and shaken ; the difference gives an indication of the relative irregularity and size of grain.

The gravimetric density of unglazed powder, made in pounding mills, is about 850 ; the following results were obtained from some of the best powder made in the United States, in cylinder mills :

SIZE OF GRAIN.	Specific gravity.	No. of grains of powder in 10 grs. Troy.	Weight of 1 cubic foot.		Cubic inches in 1 lb. loose.
			Loose.	Shaken.	
			oz.	oz.	
Cannon - -	1,630	350	922	1,000	30
Musket - -	1,538	700	900	990	31
Rifle - -	1,535	16,000	860	960	32
Sporting - -	1,800	35,000	885	1,030	31

The specific gravities stated in the above table were obtained by means of mercury ; the results are not perfectly accurate, as the method is liable to some objections. The following method of ascertaining the specific gravity of gunpowder is given as that pursued in the French manufactories, but it is also not free from objections. The specific gravity of the sporting powder of the above table obtained by this method is 1,890, and that obtained approximately, by direct measurement and weight of pieces of dried mill cake, is about 1,900.

Determination of the Specific Gravity of Gunpowder.

The instrument used for this purpose is a cylindrical glass vessel of uniform diameter, the edges of which are well ground and to which is adapted a cover of polished glass accurately ground on the surface, so as to close the vessel hermetically. The diameter of the vessel is 3 in., and its height 4.5 in. With a good balance take the exact weight of the vessel and cover.—Fill the vessel with distilled water and cover it so as entirely to exclude the air ; this may be effected by pouring in the water until it runs over the sides of the vessel, and then sliding the cover on—wipe the vessel and the cover perfectly dry, without disturbing the cover so as to admit air into the vessel.—Ascertain the weight of the vessel thus filled, and deducting its weight when empty, set down the weight of distilled water which it contains, which weight we will designate by *W*. Now wipe the vessel and cover perfectly dry, and ascertain in the same manner the weight *W'* which the vessel will contain of water saturated with nitre, such as is used in testing the purity of saltpetre—pour out three-fourths of the saturated solution, and

having weighed 1500 grains of powder free from dust, pour it *slowly* into the saturated solution, so that the air between the grains of powder may escape—then fill the vessel with the solution, and cover it as before; wipe it dry and ascertain the weight. From the weight thus found, subtract that of the vessel and cover, and that of the powder; the remainder will be the weight of the saturated solution in the vessel; deduct this weight from that W' of the saturated solution, before obtained, and the difference will be the weight w' , of the quantity of the solution which occupies the same space as the given quantity of powder. Then $W' : W :: w' : w$, the weight of distilled water which would have been displaced by the powder; and this weight is to that of the powder as the specific gravity of distilled water is to the specific gravity of the powder. Repeat the operation three times, and take the mean result.

PACKING POWDER.

Government powder is packed in barrels of 100 lbs. each. Powder barrels are made of well seasoned white oak, and hooped with hickory or cedar hoops which should be deprived of their bark; the cedar is not so liable as hickory or white oak to be attacked by worms, and it should therefore be used in preference, or the hoops may be prepared by immersion in a solution of corrosive sublimate. The hoops should cover two-thirds of the barrel. The diameter of the bung hole is 1.25 in.—Instead of a bung on the side, a screw hole 1.5 inch in diameter has latterly been made in the head of the barrel; it is closed by a wood screw with an octagonal head which must not project beyond the ends of the staves; under the head of the screw is a washer of thin leather steeped in a solution of beeswax in spirits of turpentine. This screw plug renders it unnecessary to take out the head of the barrel, and the hoops may therefore be secured with copper nails; for transportation, a piece of cloth should be glued over the head of the plug.—Some barrels have been made with six copper hoops, and others with 4 copper and 8 or 10 cedar hoops; the copper hoops are 1 in. wide, and $\frac{1}{8}$ of an inch thick, fastened with two rivets, and nailed each with 3 copper nails, 0.625 in. long—Average weight of a hoop $2\frac{1}{4}$ lbs.

In 1836, some barrels were made water proof by a lining of India rubber cloth, to ascertain its efficiency in preserving the powder in damp situations, or in the exposure of service in the field.

Dimensions of Powder Barrels.

Whole length	-	-	-	-	20.5 inches.
Length, interior, in the clear	-	-	-	-	18 "
Interior diameter at the head	-	-	-	-	14 "

Interior diameter at the bilge - - - 16 inches.

Thickness of the staves and heads - - - 0.5 "

Weight of the barrel with cedar hoops - - - 25 lbs.

The barrels have generally 12 cedar hoops, 14 to 16 staves, and 2 or 3 pieces in each head. The above dimensions are calculated so that, with 100 lbs. of powder, there shall be a vacant space in the barrel, allowing the powder to shake, in order to prevent its caking—the barrel would contain about 120 lbs. of powder settled by shaking.

INSPECTION AND PROOF OF POWDER.

Gunpowder should be of an even grain, angular and irregular in form; it should be so hard as not to be easily crushed by pressure with the finger; it should, when new, leave no trace of dust when poured on the back of the hand, and should leave no beads or foulness when flashed, in quantities of 10 grains, on a copper plate. The size of the grain for each kind of powder has been regulated as follows: There are three sieves or gauges for each size of grain, *cannon*, *musket* and *rifle*; the holes in two of these sieves (Nos. 1 and 3) have the sizes above given for the maximum and minimum sieves, (page 151,) and the other (No. 2) a mean size between them; 1 lb. of powder sifted through these gauges should leave a small portion, not more than 1 oz., on No. 1; not more than 3 oz. should pass through No. 3; and of the remainder, not more than one-half should pass through No. 2. Ordinarily, the uniformity and size of the grain will be judged of by mere inspection.

The powder in each barrel is proved. For this purpose a sample of about $3\frac{1}{2}$ oz. is taken from each; this is conveniently done by means of an *extractor*, which is a copper tube about 1 in. interior diameter, and 18 in. long, pointed at the bottom, and having a valve at the lower end, or an opening about 9 in. from that end, by covering which with the hand the powder may be poured out of the mouth of the tube; the sample is put into a tin canister marked with a number, a corresponding one to which is inscribed with chalk on the barrel; from these samples, the charges for the *eprouvette* are weighed on the proving ground, as they are required.

The platform for the mortar *eprouvette* should be a block of oak timber firmly established on a foundation of masonry, with which it is connected by strong bolts; to this block the iron bed plate is fixed by the three bolts provided for that purpose, the plate being also let into the wood about 0.5 in., to avoid bending the bolts. The ground where the balls are to fall should be free from stones and not too hard.

The *eprouvettes* are provided with 3 service balls and a standard ball (marked

No. 1,) by means of which and of the standard powder accompanying each eprouvette, the mortar and the service balls should be verified from time to time.

The eprouvette, being washed clean and dried by firing a scaling charge, is placed on its bed, in a vertical position, in which it is supported by a wedge or prop; the vent is stopped with a copper wire having a shoulder to prevent it from projecting into the chamber, and the charge of powder is introduced through a long funnel which is supported on the bottom of the bore, at the mouth of the chamber; the ball is then carefully lowered down by means of a hook, and the mortar placed on its bed, care being taken not to jar it roughly; it is primed with a small strand of quick match and fired without delay. Two charges are fired in this way from each sample of powder, and if the ranges differ more than 20 yards, a third charge is fired, and the two nearest ranges are used in obtaining the mean range. The mortar is scraped and wiped after each discharge, and it is washed and dried, as at first, after about 8 shots.

The general mean range of new powder proved at any one time must be not less than 250 yards; but no powder ranging below 225 yards is received. The powder in magazines is considered unserviceable if it does not range over 180 yards.

With the eprouvettes, as adjusted in 1837, good cannon powder ranges from 280 to 300 yards, and small grain powder, from 300 to 320 yards.

INSPECTION REPORT. The report of inspection should show the place and date of fabrication and of proof—the kind of powder and its general qualities; as, hard or soft, round or angular, whether free from dust or not, of uniform or irregular grain—its gravimetric density—the separate ranges and the mean range—the condition of the mortar and the ball—the state of the weather.

MARKS. Each barrel is marked on one head with the place and year of manufacture, and with the kind of grain, *cannon*, *musket*, or *rifle*; on the other head, with the year in which it was proved and the proof range, leaving room for subsequent proofs which are marked in the same manner.

Remarks.

Although the above is the established mode of proof and inspection for Government powder, it cannot be disguised that a very imperfect test of the relative projectile force of gunpowder is thereby afforded. Slight variations in the density of powder, which would but little affect its strength, when fired in large quantities, produce great differences in the proof range; and variations in the size of the grain cause still greater irregularities in the range, the powder being in other respects the same. In general, gunpowder of *small grain* and *low*

specific gravity gives the highest range in the eprouvette, whilst recent experiments with the ballistic pendulum have shown that the greatest initial velocity in a shot from a heavy gun (32-pdr.) is produced by powder of *great specific gravity* and of *very coarse grain*, made in a graining sieve the holes of which are 0.25 in. in diameter, giving 130 grains of powder to 10 grains troy.

PENDULUM EPROUVETTE. The best mode of testing the projectile force of gunpowder is undoubtedly that of ascertaining its effects when used in the same quantities in which it is to be employed in service; this method has been recently adopted in France, by the establishment of a ballistic pendulum and a pendulum cannon, in which a gun of any calibre may be used.

MUSKET PROOF. The strength of powder for small arms may be tried by firing a given charge from a musket barrel mounted as a pendulum, or by firing a steel ball into a target of thin boards.

The following method was adopted in some experiments for this purpose. The musket barrel was mounted on a strong frame which prevented recoil and to which it was secured by hinged bands, keyed down so as to be easily loosened for the purpose of cleaning the barrel—it was charged with 100 grs. of powder kept in its place by a patch of soft leather or paste board, such as that used by sportsmen, and rammed slightly, as uniformly as possible—the steel ball had about 0.01 in. windage, and was retained by a similar patch—the barrel was scraped and wiped after each discharge, and washed and dried with a blowing charge, after two shots with the same kind of powder—the target was composed of elm boards 0.5 in. thick, wetted, and placed in a frame, 0.75 in. apart, at the distance of 40 feet from the muzzle of the piece. The powder was sifted to obtain a uniform grain, being that which passed through the *medium* sieve and not through the *minimum*—the results obtained in this way were perfectly uniform with the same kind of powder.

The musket powder referred to in the Table on page 153 gave a penetration through 15 boards; the rifle powder, 16; and the sporting powder, 18. These are perhaps to be regarded as *maximum* penetrations for each kind of grain, and musket powder giving a penetration of 11 or 12 would be still serviceable.

HYGROMETRIC QUALITIES. The susceptibility of powder to absorb moisture may be judged of by exposing 1 lb. to the air, in a moist place, (such as a cellar which is not too damp,) on a glazed earthen dish, for 15 or 20 days, stirring it sometimes so as to expose the surface better; the powder should be previously well dried, at a heat of about 140°. Well glazed powder, made of pure materials, treated in this way, will not increase in weight more than 5 parts in 1000, or a half of one per cent. Such powder kept in casks in a dry magazine will

absorb about 8-10ths of 1 per cent. of moisture. A sample thus kept for 15 years in a common barrel was found to lose but 9-10ths of 1 per cent. in drying.

QUICKNESS OF BURNING. The relative quickness of two different powders may be judged of by burning a train laid in a circular or other groove which returns into itself, made in a piece of hard wood; one-half of the groove being filled with each kind of powder, and fire communicated at one of the points of meeting of the two trains, the relative quickness is readily deduced from observation of the point at which the flames meet. For this purpose it is necessary that the two powders compared should be of equal grain, and the method is best applied to the comparison of fine grained powders which can be laid evenly in the groove; for such powder, a groove whose cross section is a semicircle of $\frac{1}{8}$ of an inch diameter, and its length 20 feet, divided into tenths of a foot, will be found convenient.

Whatever may be the mode of proof adopted, it is essential, in judging of the qualities of gunpowder, to know the mode of fabrication, and the proportions and degree of purity of the materials; the latter point may be ascertained by analysis.

ANALYSIS OF GUNPOWDER.

TO DETERMINE THE QUANTITY OF SALTPETRE. In a vessel of tinned copper, like a common coffee pot, dissolve 1000 grains of powder, well dried before weighing, in 2000 grains of distilled water, and heat it until it boils—let it stand a moment, and then decant it on a piece of filtering paper doubled exactly in the middle; repeat this operation 4 times—at the 4th, instead of decanting, pour the whole contents of the vessel on the filter—drain the filter and wash it several times with 2000 grains of water heated in the vessel, using in all these operations 10,000 grains of water. After passing through the filters, this water contains in solution all the saltpetre, the quantity of which is ascertained by evaporating to dryness. Dry the double filter with the mixture of coal and sulphur, and take the weight of this composition by using the exterior filter to ascertain the weight of that on which the composition remains; this weight serves to verify that of the saltpetre, and to estimate the loss in the process. By expelling the sulphur from this composition by heat, the quantity of coal, and consequently of sulphur may be found, but this operation is tedious and delicate.

TO DETERMINE THE QUANTITY OF SULPHUR DIRECTLY. Mix and beat in a mortar 10 grains of dry powder, 10 of subcarbonate of potash, 10 of saltpetre, and 40 of chloride of sodium—put this mixture in a vessel (capsule) of platinum or glass, on live coals, and when the combination of

the materials is completed, and the mass is white, dissolve it in distilled water, and saturate the solution with nitric acid—decompose the sulphate which has been formed, by adding a solution of chloride of barium, in which the exact proportions of the water and the chloride are known. According to the atomic proportions, the quantity of sulphur will be to that of the chloride of barium used, as 20.12 to 152.44.

TO DETERMINE THE QUANTITY OF CHARCOAL DIRECTLY. Mix 1000 grains of powder with an equal quantity of caustic potash, (or of subcarbonate of soda or potash) and a little water; boil the mixture for some time, and pour it on a double filtering paper—when the liquor, which is of a deep yellow color, is filtered, wash the filter several times with distilled water, until the water comes off tasteless, or until it gives no precipitate with acetate of lead—then dry the charcoal and weigh it. Repeat the operation two or three times. The results thus obtained may be verified by composing a powder in the proportion indicated, and analysing it in the same way; the new results will show the corrections necessary in the first.

RESTORING UNSERVICEABLE POWDER.

When the quantity of water absorbed by gunpowder does not exceed 7 per cent., the powder may be restored by drying; this may even be effected in the magazine, if it is dry, by means of ventilation, or by the use of the chloride of lime, for 20 or 30 days. Quick lime may be used, but the use of it is attended with danger on account of the heat evolved in slaking.

When powder has absorbed from 7 to 12 per cent. of water, it may still be restored by drying in the sun or in a drying house; but it remains porous and friable, and unfit for transportation: in this case it is better to work it over. In service, it may be worked by means of the rolling barrels, as described for making round powder.

When powder has become mixed with dirt or gravel, or other foreign substances which cannot be separated by sifting, or when it has been under water, or otherwise too much injured to be re-worked, it must be melted down, to obtain the saltpetre by solution, filtration and evaporation.

PRESERVATION, STORAGE, AND TRANSPORTATION.

In the powder magazines, the barrels are generally placed on the sides, three tiers high, or four tiers, if necessary; small skids should be placed on the floor, and between the several tiers of barrels, in order to steady them, and chocks should be placed at intervals on the lower skid to prevent the rolling of the barrels. The powder should be separated according to its kind, the place and date of

fabrication and the proof range. Fixed ammunition, especially for cannon, should not be put in the same magazine with powder in barrels, if it can be avoided.

In a room 13 or 14 feet wide, the barrels may be arranged in a double row in the centre, two alleys $2\frac{1}{2}$ feet wide, and 2 single rows 6 to 12 inches from the walls; in this way the marks of each barrel may be seen, and any barrel can be easily reached. In a room 12 feet wide, an equal number of barrels may be placed in two double rows, with a central alley of 3 feet, and 2 side alleys, next the walls, of about 10 in. each: there should be an unencumbered space of 6 or 8 feet at the door or doors of the magazine.

Should it be necessary to pile the barrels more than 4 tiers high, the upper tiers should be supported by a frame resting on the floor; or the barrels may be placed on their heads, with boards between the tiers.

Besides being recorded in the magazine book, each parcel of powder should be inscribed on a ticket attached to the pile, showing the entries and the issues.

For the preservation of the powder and of the floors and lining of the magazine, it is of the greatest importance to preserve unobstructed the circulation of air, under the flooring as well as above. The magazine should be opened and aired in clear, dry weather; the ventilators must be kept free; no shrubbery or trees should be allowed to grow so near as to protect the building from the sun. The moisture of a magazine may be absorbed by chloride of lime suspended in an open box under the arch, and renewed from time to time; quick lime, as before observed, is too dangerous.

The sentinel or guard at a magazine, when it is open, should have no fire arms, and every one who enters the magazine should take off his shoes, or put socks over them; no sword, or cane, or any thing which might occasion sparks should be carried in.

Barrels of powder should not be rolled for transportation; they should be carried in hand barrows, or slings made of rope or leather. In moving powder in the magazine a cloth or carpet should be spread; all implements used there should be of wood or copper, and the barrels should never be repaired in the magazine; when it is necessary to roll the powder for its better preservation and to prevent its caking, this should be done, with a small quantity at a time, on boards, in the magazine yard.

In wagons, barrels of powder must be packed in straw, secured in such a manner as not to rub against each other, and the load covered with thick canvass.

LIGHTNING RODS.

Extracted from a Report of the French Academy of Sciences.

In a lightning rod there may be distinguished two principal parts; the pointed *stem*, and the *conductor* with its roots.

The stem or upper part of the rod is a bar of square or round iron, or copper, drawn out into a pyramidal or conical form, 13 to 20 feet high, (according to the height of the building and of the surrounding objects,) and from 1.25 in. to 2 in. thick at the base, in order to give it sufficient stiffness in proportion to its height. The upper end is made of a conical brass rod 20 in. long, gilt at the top, or pointed with platina which is united to the brass with silver solder, the joint strengthened by a small brass collar. The iron and brass rods are joined together by an iron dowel, screwed into both, and secured by iron pins. The brass point may be used without being gilt or armed with platina.

The *stem* should be made, if possible, in one piece; if it becomes necessary to divide it, the joint should be at about one-third of the height from the bottom; the two parts connected together by a tapering tenon in the upper piece, and a corresponding mortice below, secured by an iron pin; or, the two parts may be screwed together. At the bottom of the stem, above the roof, is a shoulder or flanch to throw off the rain water which might otherwise follow down the rod into the roof; just above this flanch the stem is rounded about 2 in. in height, to receive a hinged collar with two *ears* between which the end of the conductor is secured by a bolt; or the stem and the conductor may be connected by a *square collar* or *strap*, and a cross bar, which is fastened over the conductor by two nuts screwed on the ends of two branches of the strap which pass through holes in the cross bar; the back of this strap has a *branch* projecting upwards, which is secured by a bolt to a *fork* formed in the end of the conductor.

The stem is fixed to the building in various ways, according to circumstances. The best method is to attach it to a chimney or gable, where it may be secured by straps passing round the chimney, or through the wall, keyed inside against an iron bar. On an arch, the stem terminates in three or four branches or *feet* which are leaded into the masonry.

The *conductor* is made of bars of square or round iron or copper, from 0.5 in. to 1 in. thick, connected together by a bevel joint in the form of a *Z*, fastened by 2 pins; or the bars may be screwed together. The conductor runs parallel to the roof, from 4 in. to 6 in. above it, and is supported, at intervals of about 10 feet, by *forks*, the lower ends of which are not pointed, but flattened and bent at a right angle and nailed to a rafter, to prevent the filtration of water into the wood; the rod is held in each fork by a rivet through the branches above the rod.

The conductor follows the cornice of the building without touching it, and descends in like manner along the wall, to which it is fastened by *cramps* or *staples*. About 18 in. below the surface of the ground, it is bent perpendicularly to the wall and extended in that direction about 15 feet, when it passes into a well, or if water is not met with, into a pit 15 feet deep, which may be filled with loose paving stones, if it is not convenient to let it remain as a well.

To facilitate the transmission of the electric fluid, and to prevent the rod from becoming rusty, it is enclosed in a trough filled with well burnt charcoal, which should be packed about 1.5 in. thick all round the rod; this trough may be made of bricks, or of stone, tiles, wood, &c. The conductor passes out of this trough through the sides of the well; if the latter is within the building, the conductor should pass through the wall under ground. The communication should not be made with a well or cistern which is resorted to for use.

The conductor terminates generally in two or three *prongs* or roots, which should be so placed, if possible, as to be always immersed in water not less than 2 feet; in a dry well, the roots should be covered with charcoal well rammed, and the rod within the well should be enclosed in a pipe or trough filled with charcoal. In rock or dry ground, if the conductor cannot be led into moist earth, increase the number of branches. Lead the rain water, if practicable, over or through the trough which contains the rod, and into the well.

Chains or *ropes of metallic wire* may be used for conductors, and are convenient in some situations, but rods are preferable. Copper wire is better than iron for this purpose.

The greatest care must be taken, both in fixing the rod and in its subsequent preservation, to keep the communication perfect through every part of it; otherwise it will be *dangerous* instead of useful.

It is considered that a lightning rod can protect a circular space the radius of which is double the height of the rod above the roof of the building; but when it is attached to an elevated part of the building, such as a tower or steeple, it is safer to rely on its protection to the extent only of its height above the body of the building, and to erect others for protecting the more distant parts.

A building is better protected by two rods of 15 to 20 feet high placed at a distance equal to the sum of their radii of action, than by one rod of double the height.

All the large pieces of metal about a building, such as metallic coverings of the roof, ridges, fastenings, gutters, and long bars, should communicate with the conductor through bars or wires about 0.25 in. thick; it is better, in this respect, not to use such materials in building when they are not indispensable;

nothing is to be apprehended from the common iron work of buildings, as hinges, locks, &c.

The conductor should be carried to the ground in the shortest line; one conductor may sometimes be made to communicate with two stems, without increasing its diameter: there should be not less than two conductors for *three* stems or points; the feet of several conductors may be made to communicate with each other.

Conductors should be generally placed on the side towards the prevalent storms; the walls of that side being oftenest wet by the rain might otherwise cause accidents, by acting as imperfect conductors.

Lightning rods for powder magazines are attached to *masts* or poles planted from six to ten feet from the walls of the building: the *stem* of the rod need not be thicker than the conductor or more than 6 feet high, but the mast should be of such a height that the point of the stem may be about 15 feet above the building. If a lightning rod is placed *on* a magazine it will be prudent to have two conductors to it; one on the side of the prevailing storms, the other on the opposite side.

Pictures and Furniture.

1. *Furnace room.* Furnaces; benches for standing and trimming balls; planer blocks, or large scales; a tinner's bench and tools, with a vice, an anvil and a chisel for tools; a smith's shovel and poker; stools, &c. In this room may also be placed, if required in the laboratory, a turning lathe, and a carpenter's bench, with a tool chest for each.

2. *Cartridge room.* A table for making cartridges for small arms, 12 feet long and 3½ feet wide, for 12 men or boys to work at, and the breadth in that proportion for any greater number; tables for cutting paper and flannel, and for rolling cases on; chairs for locked cases; paper for velvet and portfire cases; benches for cartridge tables; stools. Two stools should be positioned off from

CHAPTER NINTH.

AMMUNITION AND MILITARY FIREWORKS.

LABORATORY.

Buildings.

The rooms required for a laboratory are :

1. *Furnace room*, for casting bullets and making compositions requiring the use of fire.
2. *Cartridge room*, for making paper and flannel cartridges of all kinds.
3. *Filling room*, for filling cartridges for cannon and small arms.
4. *Composition room*, for mixing compositions.
5. *Driving room*, for driving rockets, portfires, fuzes, &c.
6. *Packing room*, for putting up ammunition for transportation or storage.
7. *Magazine*, or storehouse for powder and fixed ammunition, &c.

These rooms are sometimes arranged, for greater security, in several separate buildings, protected by trees or traverses of earth ; but it is more convenient to have them under one roof, (except the furnace room and the magazine,) or connected by covered passages. The laboratory should be apart from inhabited buildings. The size of the rooms must be regulated by the number of artificers to be accommodated, and in small establishments, the number of rooms may be reduced, as the same room may be used, at different times, for different purposes.

Fixtures and Furniture.

1. *Furnace room.* Furnaces ; benches for running and trimming balls ; platform balance, or large scales ; a tinner's bench and tools, with a vice, an anvil and a chest for tools ; a smith's shovel and poker ; stools, &c. In this room may also be placed, if required in the laboratory, a turning lathe, and a carpenter's bench, with a tool chest for each.
2. *Cartridge room.* A table for making cartridges for small arms, 12 feet long and $2\frac{1}{2}$ feet wide, for 12 men or boys to work at, and the length in that proportion for any greater number ; tables for cutting paper and flannel, and for rolling cases on ; choker for rocket cases ; press for rocket and portfire cases ; benches for cartridge tables ; stools. Two closets should be partitioned off from

this room, and furnished with cases, drawers, racks, and shelves; one closet for materials, the other for tools.

3. *Filling room.* A shelf 2 feet wide for weighing on; other shelves with closets under them; tables with raised borders for filling, folding, &c.; budge barrels, or powder barrels with copper hoops and covers; stools for seats; foot stools; a step ladder; stands and gutters for emptying powder barrels.

4. *Composition room.* Shelf for weighing on; shelves, drawers and closets; tables; mealing tables, with raised borders; stools for seats; foot stools; step ladder.

5. *Driving room.* Blocks set in the ground or pavement, through the floor; benches and stools.

In favorable weather, a porch attached to the building, or a tent, may be used for a driving room.

6. *Packing room.* Tables, benches and stools; platform balance.

7. *Magazine.* Shelves and frames, for boxes and barrels.

Furnaces.

Two kinds of furnaces are used in a laboratory: in the first, the flame circulates around both the bottom and sides of the kettle; in the second, it comes in contact only with the bottom; the latter are used for compositions of which gunpowder forms a part.

Furnaces are built of brick; the kettle is of cast iron, about 2 feet in diameter at the top, having a rounded-bottom and a flange about 4 inches wide around the top, or else strong handles, to set it by. The bottom is 0.75 in. thick, and the sides 0.5 in. By setting it in an iron plate pierced with holes, encircling the bottom, a furnace of the first kind may be converted into one of the second kind by stopping the holes.

In the field, furnaces may be built with sods, or sunk in the earth, if bricks cannot be readily procured.

Furnace built with sods. Let the kettle rest on a trivet the feet of which may stand on any piece of flat iron, such as the bottom of a shot canister, or stand for grape; the bottom of the kettle about 1 foot from the ground; build round it with sods; the door of the furnace is 10 in. square; the flue of the chimney, opposite to the door, 6 inches square, and commencing about 6 in. from the ground; the first part of the flue inclined at an angle of about 15° , the rest vertical and placed, if circumstances permit, against a wall; the top of the door and of the flue may be supported by small bars of iron.

Furnace sunk in the earth. The edge of the kettle should be 1 foot above the ground, and the bottom 1 foot above the hearth of the furnace; the earth is dug out so as to give access to the door; the flue is bored out on the opposite

side, with a crowbar ; it commences 6 in. above the hearth and comes out of the ground 18 in. from the furnace, whence it is carried horizontally about 13 feet.

In furnaces of the second kind mentioned above, the trivet may be omitted, and the kettle may rest on the sod or earth, for about 1 in. all round.

Tools and Implements.

The following list of laboratory tools and implements shows the kinds and proportions which may be required for a large laboratory and for a park of artillery.

KIND.	QUANTITY.	
	Laboratory.	Park.
Adze, copper, weighing 5 lbs.	1	
Awls	100	6
Bags, leather, for pulverizing powder, &c.	2	2
Balls, brass or zinc, { 0.75 in. diameter, for pulverizing sulphur lbs.	100	40
{ 0.35 in. diameter, for pulverizing other materials lbs.	200	80
Barrel for rolling leaden balls	1	
Barrel for pulverizing, { sulphur	1	} 1
{ gunpowder	1	
{ compositions	1	
Bench, for drawing the loads of shells	1	
Bench stake	1	
Bick iron	1	
Bill hook	1	
Blocks, { for driving fuzes of different calibres	72	
{ for driving signal rockets and portfires	6	
{ for punches	2	
{ for cutting on	1	
Bottles, with ground glass stoppers	4	
Boxes, { for 12 workmen making cartridges, 3 to each	36	
{ for balls, &c.	50	
Bowls, { wooden, various sizes	24	12
{ earthen, glazed, large	6	
Braces and bits	2	1
Brushes, of various kinds	18	4
Buckets	6	
Callipers, various sizes	3	1
Chargers, { for fuzes	36	18
{ for portfires	4	2
copper, { for signal rockets	6	2
{ for cartridges for small arms, various sizes	20	8
Chisels, brass, for unloading shells	6	3
Cold chisels	12	6
Compasses, { common	3	1
{ spring	2	1
Coopers' drivers, copper and wood	2	2
Coopers' froe	1	1
Coopers' croes	1	
Coopers' vice, brass	1	1
Crowbar	1	1
Cutting boards	6	
Dippers	6	
Dredging boxes	6	2

KIND.	QUANTITY.	
	Laboratory.	Park.
Drifts, { of iron, pointed with copper or brass, for driving portfires - - -	12	3
{ for driving fuzes for 13 in. and 10 in. shells; long and short - -	24	8
{ for driving fuzes for 8 in. shells and howitzers; long and short -	24	8
{ for driving fuzes for 32 and 24-pdr. shells - - -	24	8
{ for driving fuzes for small shells - - -	6	2
{ for driving signal rockets, sets for 2-pdr. - - -	1	1
do. do. for 1-pdr. - - -	2	1
{ for driving serpents, iron - - -	6	2
Filtering tubs - - -	3	-
Flasks, for metal filings - - -	10	-
Formers, { of iron or wood, for portfire cases - - -	6	2
{ for rocket cases, sets for each calibre - - -	2	1
{ for serpents - - -	6	2
{ for leaders - - -	2	c
{ for small arm cartridges, of each calibre, 1 to each workman -	20	20
{ for paper cannon cartridges, for each calibre - - -	2	2
{ for cylinders & caps, do. - - -	2	1
{ for mortar cartridges, do. - - -	1	-
{ for pots for rockets, do. - - -	1	1
{ for cutting pots on, do. - - -	1	1
{ for cones for rockets, do. - - -	1	1
{ for wads, do. - - -	1	-
Fork, iron, for dipping pitched facines - - -	1	o
Frames for rolling barrels - - -	4	-
Funnels, of copper and tin, various kinds - - -	28	28
Fuze setters, { for large shells - - -	2	1
{ for small shells - - -	4	2
Fuze extractors - - -	2	1
{ steel, for shot and shells; for each calibre - - -	2	2
{ double, for grape and canister, do. - - -	1	1
{ do. for cartridge formers, do. - - -	1	1
{ do. for priming tubes - - -	4	1
Gauges, { of sheet iron, for shot blocks; for each calibre - - -	1	1
{ do. for canister bottoms, do. - - -	1	-
{ do. for canisters - - -	1	-
{ of copper or wood, for cannon cartridges - - -	1	1
Gimlets - - -	2	2
Gimlets for priming rockets - - -	6	3
Glue pot and brush - - -	1	-
Grate, for drying shells - - -	1	-
Hammers { iron, hand, for strapping shot, &c. - - -	13	12
{ copper - - -	2	1
Handbarrows, with rope or leather bottoms, for powder barrels -	2	-
Handspikes - - -	10	-
Hatchet - - -	1	1
Hooks for unpacking ammunition boxes - - -	6	3
Hurdles - - -	8	-
Injector, for filling tubes - - -	2	1
Kettles, { iron, for melting lead - - -	2	1
{ do. for firestone, &c. - - -	2	-
{ do. for pitch, - - -	1	1
{ copper, for paste - - -	2	1
Knives, { for cutting paper, large and small - - -	12	6
{ block - - -	1	1
Ladles { iron, for lead, pitch, &c. - - -	5	1
{ copper, for saltpetre, &c. - - -	1	1
Lanterns - - -	5	5
Letter punches, (stencils,) set - - -	1	-

KIND.	QUANTITY.	
	Laboratory.	Park.
Mallets, { for driving fuzes and portfires	48	20
Mallets, { for driving rockets	6	4
Mallets, { carpenter's	2	-
Mauls, wooden, for crushing powder and charcoal	2	1
Measures, { for powder, from 8 lbs. to 4 lbs.	22	22
Measures, { gallon, quart, pint, half pint and gill	5	-
Mortar and pestle, bronze	1	1
Mortar, marble, with pestle of hard wood	1	-
Moulds, { for balls and buckshot, sets	18	6
Moulds, { for incendiary balls, different calibres	4	-
Moulds, { brass, (or cylinders of copper or tin,) for portfires	4	2
Moulds, { for rockets, of each calibre	2	1
Moulds, { for casting tubes	12	-
Mullers, wooden	4	2
Needles, of various kinds	150	24
Nippers, { for cutting wire,	2	1
Nippers, { for trimming balls	6	3
Palms, for quilting grape and sewing canvass	4	2
Paste brushes	12	12
Patterns, { for cartridge papers for small arms	4	2
Patterns, { tin or wood, of each kind and calibre for paper cartridges	1	1
Patterns, { do. do. do. for flannel cartridges	1	1
Patterns, { do. do. do. for canisters	1	1
Pans, copper, various sizes	18	6
Picks	2	-
Pitchers, stone	6	-
Pliers, flat, for twisting wire	4	2
Press, for paper and pasteboard	1	-
Profiles, of sheet steel, for shot blocks, for each calibre	1	-
Punches	6	-
Punches, { for piercing shot straps	12	12
Punches, { centre	4	-
Punches, { for fuze caps; for 13 in., 10 in., 8 in., and 24 pdr., 2 each	8	-
Rakes, iron	2	-
Rasps, for wood	6	6
Reels, or frames, for quick match	2	1
Rocket stand	1	-
Rolling boards, for portfire cases, &c.	4	1
Rules, { carpenter's	2	1
Rules, { iron, for cutting by	8	2
Rules, { wooden, 2 of 6 feet each	8	-
Sand stones, for sharpening knives	6	2
Saw knives	2	2
Scale of 1 foot, (diagonal) divided into inches and 100ths	1	1
Scales, copper, large, small and medium	5	2
Scissors and shears of different sizes; one pair for each cartridge maker	12	6
Scoops, copper, for taking up materials	6	-
Screw drivers	4	2
Scribes	4	2
Shell plug screws	8	2
Sieves, { hair, Nos. 1, 2, 3 and 4, with frames	4	4
Sieves, { bolting cloth	2	2
Screen, { or riddle, of metal, for screening leaden balls	2	-
Screen, { of brass wire, to separate the pulverizing balls	1	1
Screen, { for demolition of cartridges for small arms	2	-
Shovels	2	-
Skimmer, copper, for saltpetre	1	1
Soldering furnaces and irons	2	-
Socks, pairs	60	-
Spatulas, iron, for saltpetre	3	-

KIND.	QUANTITY.	
	Laboratory.	Park.
Spatulas, { for fire stone - - - - -	6	-
{ for packing ammunition boxes - - - - -	24	2
Spoke shave - - - - -	1	-
Spools, for twine, - - - - -	40	-
Squares, { wooden - - - - -	6	2
{ iron - - - - -	2	1
Stamps for flannel cartridges, for each calibre - - - - -	1	-
Tarpaulins - - - - -	4	-
Thimbles - - - - -	6	3
Tinner's crease - - - - -	1	-
Tinner's shears - - - - -	2	1
Tinder box and steel - - - - -	1	1
Trestles, pairs - - - - -	2	-
Trivets, iron - - - - -	2	-
Trough, for the demolition of cartridges for small arms - - - - -	1	-
Tubs, { common - - - - -	6	-
{ for making slow match, &c. (casks sawed in two) - - - - -	6	-
Twisting machine, for match rope, &c. - - - - -	1	-
Watering pots - - - - -	2	-
Weights, sets for each balance or pair of scales - - - - -	1	1
Wires, brass, for piercing priming tubes - - - - -	1000	100
Yard stick, - - - - -	1	1

Powder Measures.

Made of sheet copper; those for use in the park should be made without handles, for the convenience of putting them up in a nest; their form is cylindrical, the interior diameter and height being equal.

To find the diameter and height of a cylinder to contain a given quantity of gunpowder : Multiply the weight in pounds by

38.2	for cannon powder	} of medium density,
39.45	for musket powder	
40.7	for rifle powder	

and take the cube root of the product.

DIMENSIONS OF POWDER MEASURES.

Weight of powder.		Diameter and height.	Weight of powder.		Diameter and height.
lbs.	oz.	Inches.	lbs.	oz.	Inches.
0	1	1.337	2	0	4.240
0	2	1.685	2	8	4.571
0	4	2.122	3	0	4.857
0	8	2.673	4	0	5.346
1	0	3.368	4	8	5.560
1	4	3.628	6	0	6.120
1	8	3.855	8	0	6.736

Precautions against accidents.

Avoid, as much as possible, the use of iron in the construction of the buildings, fixtures, tables, &c., of the laboratory; sink the heads of iron nails if used, and paste paper or putty over them; cover the floor with oil cloth or carpets; have it frequently swept.—Let the workmen in the powder rooms wear socks, and take them off when they go out.—Keep no more than the requisite quantity of gun powder in the laboratory, and have the ammunition and finished work taken to the magazine.—Let powder barrels be carried in hand barrows made with leather, or with slings of rope or canvass, and the ammunition in boxes—Let every thing that is to be moved be lifted, and not dragged or rolled on the floor—Never drive rockets, portfires, &c., in a room where there is any powder or composition, except that used at the time—Never enter the laboratory at night, unless it is indispensable, and then use a close lantern, with a wax or oil light carefully trimmed—Allow no smoking of tobacco near the laboratory.

MATERIALS.

NOTE. The proportions are by *weight*, and the temperatures, in degrees of Fahrenheit's thermometer.

SALTPETRE. For use in the laboratory, saltpetre must be reduced to impalpable powder, or else to very minute crystals. It is best pulverized in the rolling barrels at the powder mills, but it may be pulverized by hand in the laboratory, as follows: Put into a *rolling barrel* 50 lbs. of dry refined saltpetre, and 100 lbs. of balls; turn the barrel for two hours and a half at 30 revolutions a minute, striking it, at the same time, with a mallet to prevent the saltpetre from adhering to the sides. Separate the balls by means of a brass wire screen, and the foreign substances, with a hair sieve.

Saltpetre may also be pulverized by pounding it in a brass mortar, or by solution, as follows: Put 14 lbs. of refined nitre, with 5 pints of clear water, in a broad and shallow copper pan over a slow fire, and as the nitre dissolves, skim off the impurities; stir the solution with a wooden spatula until the water is all evaporated, when the nitre will be very white and fine. Should it boil too much, the pan must be lifted from the fire and set upon wet sand or earth, and the saltpetre should be stirred until it dries, to prevent it from adhering to the pan.

CHARCOAL. To make charcoal fit for laboratory use: Bury an iron kettle in the earth, to within 4 inches of the edge; put small pieces of wood against the sides; set fire to them, and add wood as it burns, covering that which is already charred; stir it with a poker, from time to time, until the kettle is full of charcoal; then put on a cover, and when vapor ceases to come over, cover it with earth; at the end of 48 hours, take out the charcoal and separate the wood which is imperfectly charred.

Charcoal should be kept in close barrels, in a dry place. For use, when not previously pulverized, it is put into a rolling barrel with 4 times its weight of bronze balls, and run for half an hour; it is then screened and bolted. It may be pulverized also in a leather bag, in which it is beaten about five minutes with a maul; the bag should be well filled; it is held on a block and turned occasionally by one man whilst another pounds it. Charcoal for signal rockets, being used coarse, is beaten about 15 blows, and passed through a coarse and a fine sieve, using that which remains on the latter; charcoal from hard wood answers best for this purpose.

SULPHUR. When melted sulphur is to be used, care must be taken that it does not become thick, which occurs at about 320° . It is pulverized by being rolled 4 hours in a rolling barrel, with twice its weight of balls, or by being pounded in a mortar and sifted. Roll brimstone is used for melting, and flowers of sulphur may be used instead of roll sulphur pulverized, but is not so good.

GUNPOWDER. For compositions, gunpowder is *mealed*, either by rolling it for 2 hours with once and a half its weight of balls, or by beating it an equal length of time in a leather bag, or by grinding it with a muller, on a mealing table.

Mealed powder, and pulverized saltpetre, charcoal and sulphur are generally obtained, in that state, from the powder mills.

LEAD. Specific gravity 11,352—melts at 600° .

Pigs of lead frequently contain foreign matters; the fraud is easily detected by immersing the pig in a vessel of water with straight sides, so that the quantity of water displaced by the lead may be easily measured; the weight of the lead should be equal to that of the water displaced, multiplied by 11.352.

Lead melted in contact with air is soon covered by a coat of grey oxide, which rapidly increases in thickness. The formation of this oxide, or of dross, is prevented by covering the lead with powdered charcoal.

To reduce the oxide of lead. Put in a kettle about 50 lbs. of lead, with 1-10th of its weight of powdered charcoal or grease; cover the kettle, and raise to a red heat; stir the mass, and add gradually more coal, as it assumes a yellow color, using in all 1-6th of the weight of oxide; dip out the lead with an iron ladle, and pour it into iron moulds or pans. After having obtained in this way $\frac{2}{3}$ of the weight of oxide, in lead, throw the dross into a tub of water and wash it, to separate the ashes and coal; dry the remaining oxide and grains of lead, and put them in the ladle with 1-20th of their weight of rosin; raise it to a red heat, set fire to the rosin, shake the ladle, and pour off the lead; a further addition of rosin will produce more lead; 1-14th of the weight of dross is generally used. Tallow may be used in place of rosin.

When the quantity of dross is considerable, it may be reduced in a similar manner, in a furnace made of iron.

ACETATE OF LEAD, (*sugar of lead*,) is used for making slow match; it is a white efflorescent salt, of a sweet taste, very soluble in water.

PLUMBER'S SOLDER, (*soft solder*,) is an alloy of lead with $\frac{1}{2}$ or $\frac{1}{3}$ of tin; used for soldering tin.

ANTIMONY. Specific gravity 6,700—melting point 809° ; it is easily reduced to powder, and by its combustion with sulphur produces strong light and heat, with a blue or white flame. Antimony is never found pure in the shops; that which is sold under the name of *regulus of antimony* always contains a little sulphuret of antimony, arsenic, and sometimes sulphuret of iron.

COPPER, (see page 8,) being but slightly acted on by saltpetre, is employed for powder measures, utensils for refining saltpetre, &c. Copper vessels should not be exposed to a great heat, or used for heating compositions containing sulphur; the copper would be rapidly oxydized, or would combine with the sulphur, and there would be danger of explosion.

BRONZE, is used for utensils and implements liable to blows, or acting by percussion.

BRASS WIRE, for screens and sieves.

ACETATE OF COPPER, (*verdigris*,) is used to make slow match which gives a strong coal and a slight green flame.

COPPER FILINGS give reddish sparks and a greenish blue flame.

ZINC. Specific gravity 6,860—melts at 680° —is volatilized at a red heat. Heated to 400° , it may be pulverized under the hammer. It gives a bluish flame; an alloy of zinc and antimony pulverized gives beautiful blue drops. The oxide of zinc, (*flowers of zinc*,) produces the appearance called gold rain.

IRON. Filings and thin chips give very brilliant sparks and stars, the effects of which depend on the size of the particles used; the filings must be made when wanted, or be very carefully preserved from rust.

STEEL. Filings and small pieces of steel give the most brilliant sparks.

CAST IRON, pulverized, gives very large red sparks, (*Chinese fire*.) White metal, or fragments of thin pots are to be preferred; to facilitate pulverization, heat the iron red and throw it into cold water.

SHEET IRON. Choose the softest and most pliant; to make it bend easily it must be annealed by heating to a dull red, in a fire of chips, and letting it cool on a bed of hot ashes sheltered from the wind.

TIN should be very pliant, of a smooth surface, free from rust, having a white and homogeneous fracture.

(For the five preceding articles, see *Chap. 12.*)

LABORATORY PAPER.

No.	Kind.	Dimensions of sheets.	No. of sheets in a bundle.	Weight of a bundle.	Articles made with one bundle.	Quantity required for a stated number of articles.		
						No of articles.	No. of sheets.	Weight.
		Inches.		lbs.				lbs.
1	For ball cartridges -	13 by 16½	1,000	20				
	For musket - - -	- - -	-	-	12,000 Cartridges -	1,000	83½	1.66
2	For wrappers for do.	18 20	1,000	36	4,000 Wrappers -	100	25	0.9
3	For blank cartridges	15 20	1,000	30				
	For musket - - -	- - -	-	-	20,000 Cartridges -	1,000	50	1.5
	For wrappers for do.	- - -	-	-	4,000 Wrappers -	100	25	0.75
4	For port fires - - -	19 28	500	65	1,000 Cases -	1,000	500	65.
	For 1.8 in. rockets -	- - -	-	-	200 Cases -	100	250	32.5
	For 2 in. rockets -	- - -	-	-	125 Do. -	100	400	52.
5	For fixed ammuni- tion for field guns	23½ 24	500	60				
	For 6 pdrs. - - -	- - -	-	-	2,000 Cylinders, } 2,000 Caps. }	100 each	25	3.
	For 12 pdrs. - - -	- - -	-	-	1,000 Cylinders, } 1,000 Caps. }	100 each	50	6.
	For 18 pdrs. - - -	- - -	-	-	600 Cylinders, } 600 Caps. }	100 each	83½	10.
6	For cannon car- tridges	19 23	500	70				
	For 24 pdrs. - - -	- - -	-	-	500 Bags -	100	100	14.
	For 32 pdrs. - - -	- - -	-	-	333½ Do. -	100	150	21.
	For 42 pdrs. - - -	- - -	-	-	333½ Do. -	100	150	21.

No. 1 should be well sized, smooth, strong, and of even thickness; thickness of bundle pressed, 4 inches.

No. 2, of strong materials, with very little sizing.

No. 3, of ordinary materials, smooth, well sized and colored blue.

Nos. 4, 5, and 6, of best materials, even and well sized.

The several kinds to be packed in bundles; Nos. 1, 2, 3, in bundles of 1,000 sheets each; the others, in bundles of 500 sheets; all without folding. The dimensions given above are such as the sheets are required to have when trimmed for use.

A ream of paper is 20 quires of 24 sheets each.

(For the five preceding articles, see Chap. 12.)

Proof of laboratory paper. Cut a strip 4 in. wide and one foot long, in the weakest direction of the fibre of the sheet; make a loop by lapping the ends of the strip and pressing them between two rollers fixed in a frame; suspend a scale-pan by means of a hook attached to the ends of another roller resting in the bottom of the loop; these strips should sustain, before breaking, the following weights:

No.	lbs.	No.	lbs.
1	85½	4	180
2	101	5	225
3	67½	6	315

PARCHMENT, used principally for cartridges for hot shot, and for fuze caps. *Parchment paper* may be substituted for it.

PASTEBOARD, is made of 2 or 3 three sheets of paper pasted together; about 50 of the sheets of paste board are put under press for one hour, then dried separately in the shade, and put again in the press for one hour, before they become thoroughly dry.

PASTE. *Flour paste* is made best of rye flour. Sift the flour and mix it with $8\frac{1}{2}$ times its weight of water; heat it gently, stir it, and let it boil for $\frac{3}{4}$ of an hour; when it becomes ropy, pour it into bowls, and pass it through a sieve before it is quite cold. The flour yields 7 times its weight, of paste. Time required to make it, one hour and a half.

Starch paste. Mix wheat starch with twice its weight of water; pour it gradually into $6\frac{1}{2}$ times its weight of boiling water and let it boil for 10 minutes, stirring it all the time; then proceed as before. Starch yields 8 times its weight, of paste. Time required, 1 hour.

Paste for pasteboard. Mix the flour or starch with 12 times its weight of water; this yields 9 times the weight of flour, and 11 times the weight of starch.

The addition of 1-16th of glue makes the paste fit for pasting sheets of parchment together, or for pasting paper on wood. Dissolve the glue separately, and pour it into the cold water with which the flour or starch is mixed.

These different kinds of paste should be used cold. A supply for not more than 2 or 3 days should be made at one time, but it may be preserved longer by adding alum in the proportion of 1-10th of the weight of flour; the depredations of rats may be prevented by dissolving a like proportion of colocinth in the water with which the paste is made.

GLUE, should be hard, dry, transparent, of a brownish red colour, and free from smell. It is dissolved in its own weight of boiling water. A glue pot with a water bath should be used, to avoid burning the glue.

ISINGLASS SOLUTION: Dissolve 4 oz. of isinglass in 3 pints of boiling water : it is used sometimes in making quick match.

FLANNEL, WILDBORE, or SERGE, for cartridge bags, should be made entirely of wool—it should be soft, closely wove, and not frayed—the width should be even in the same piece ; that $\frac{3}{4}$ yd. wide is convenient and the most common—the colors are to be preferred in the following order ; green, grey, yellow, blue, red, white ; reject black, which is almost always burnt and weak. Wildbore and serge are to be preferred to flannel. Fabrics of cotton and flax are not used, because the powder sifts through them, and they are more apt than woollen stuffs to leave fire in the gun.

CANVASS. Take the strongest and closest wove ; used for sacks for fire balls, bags for rolling leaden balls, and in case of need, for shot straps.

TWINE, should be strong, smooth, and well twisted—0.03 in. thick for bundling cartridges, &c., and for sewing fire balls—from 0.06 in. to 0.08 in., for fixing ammunition, &c.

THREAD, for infantry cartridges ; of unbleached flax, two strands, strong and even. If home-made, it should be gently boiled for one hour in a weak lye and washed in pure water. Excellent hemp thread is obtained from the manufactories, more even, stronger and cheaper than the home-made ; it is conveniently wound in balls, and may be used without spooling it.

ROPE, should be even and well twisted ; that most commonly used in the laboratory is *white hemp rope* from 1 in. to 1.5 in. in girth. (*See Chap. 12.*)

MISCELLANEOUS MATERIALS. *Spirits of turpentine, rosin, turpentine, tar, pitch,* (*See Chap. 12.*) *petroleum, bees-wax, tallow,* are used in compositions for lighting and incendiary purposes ; *linseed oil,* in mixing some compositions, and *gum arabic* in others, to give them body and tenacity. The latter retards combustion ; the solution should be prepared as it is wanted, being liable to spontaneous decomposition.

Alcohol (Spirits of Wine,) *brandy or whiskey,* and *vinegar,* are used for mixing compositions in which saltpetre enters, because that salt is but slightly soluble in those liquids.

Lamp black is employed to give a train of rose colored fire in the air ; *common salt,* for yellow flames ; *flint glass,* in powder, for white fires ; *mica,* for rose colored sparks ; *oxide of zinc,* for blue flames.

Solutions of phosphate of ammonia and of alum, are used for rendering *paper* and *cloth* incombustible.

Other materials, used for particular purposes, will be mentioned under their proper heads.

FLINTS.

The best flints are translucent, with a smooth surface, of a uniform tint of light yellow or brown color, and slightly conchoidal fracture. They are generally obtained from England or France.

The parts of a flint are : the *edge* or *bevel*, the *back*, the *sides*, the *face*, slightly convex, and the *bed* or lower face, slightly concave ; in using the flint, the bevel is placed uppermost. There are three sizes for military service ; *musket*, *rifle* and *pistol* flints. A good musket flint will last for more than 50 fires. Flints are issued to the troops in the proportion of 1 to 20 rounds.

DIMENSIONS.	MUSKET.		RIFLE.		PISTOL.	
	Min.	Max.	Min.	Max.	Min.	Max.
	in.	in.	in.	in.	in.	in.
Whole length - -	1.20	1.50	0.97	1.20	0.93	1.10
Width - -	1.08	1.13	0.79	0.88	0.83	0.92
Thickness at the back -	0.26	0.33	0.20	0.29	0.21	0.27
Length of the bevel -	0.39	0.55	0.41	0.71	0.30	0.42

The rifle and the musketoon take the same flint. In the inspection of flints, first verify their dimensions with a gauge giving the maximum and minimum dimensions ; see that the bevel is free from spots and irregularities of surface, that the face and bed are nearly parallel and have not too great a curvature.

Packing Flints.

Flints are usually packed, for sale, in large casks, or in barrels about the size of powder barrels ; the latter will hold about 7,500 musket, 13,700 rifle, and 14,700 pistol flints.

In service, they are packed in boxes of the following dimensions :

KIND OF FLINTS.	Interior dimensions of the box.				Flints in each box.		Total weight of box packed.
	Length	Width.	Depth.	Cubic contents.	Number.	Weight	
	in.	in.	in.	in.		lbs.	lbs.
Musket -	24	11.5	8.75	2,415	5,000	111	129
Rifle -	24	11.5	4.75	1,311	5,000	66	82
Pistol -	24	11.5	3.25	897	5,000	42	55

The weights vary according to the kind of flint, the black and inferior kind being the heaviest.

The boxes should be made of pine boards 1 in. thick, planed on both sides, and dovetailed at the corners. The length and width of all flint boxes are the same; the depth only is varied to give the required capacity to boxes for different descriptions of flints. If any parcel of one denomination shall be found larger or smaller than usual, the depth of the boxes should be increased or diminished so as to contain them conveniently. A rope handle (or becket) is to be inserted in each end of the box. In boxing a large parcel, it will not be necessary that the contents of each box should be actually counted, if the flints are nearly uniform in size; after counting out accurately four or five parcels, of 5,000 each, from any cask, let each be separately weighed, and take the mean weight of the counted parcels as the basis for determining the quantity for each box, when taken from the same cask. After the flints are placed in the boxes, all the interstices are to be filled with dry sand, in order to exclude the air from them as much as possible; and for the same purpose, the boxes should be well made, of seasoned wood, and with close joints. Each box should be plainly marked on the end with the number and description of flints contained in it, and with the year in which they were manufactured, if this be known; if not known, then with the year in which they were procured.

Flints should not be placed in the upper stories of a building, but in the basement or cellar where the air is damp and cool.

CARTRIDGES FOR SMALL ARMS.

KIND.	BALLS.		CHARGES OF POWDER.				REMARKS.
	Diameter.	Number in 1 pound.	Weight.	Number in 1 pound.	Ratio to wgt. of ball.	Blank cart-ridges.	
	In.		grains.			grains.	
Musket - - - - -	0.64	18	130	54	1-3d	117	} Musket powder.
Musketoen - - - - -	0.64	18	85	82	2-9ths	77	
Hall's carbine, musket calibre - - - - -	0.64	18	75	93	1-5th	68	
Do. rifle calibre - - - - -	0.525	32	75	93	1-3d	68	} Rifle powder.
Hall's rifle - - - - -	0.525	32	100	70	4-9ths	90	
Common rifle - - - - -	0.525	32	100	70		90	
Pistol - - - - -	0.525	32	50	140	2-9ths	45	

These charges include priming, about 6 gr. to 12 gr., for all the arms except the carbine which has a percussion lock.

Buckshot are 0.3 in. in diameter; weight, about 170 to 1 lb.

Cartridges are made either with *single ball*, *1 ball and 3 buckshot*, or sometimes with *12 buckshot*, and they are designated accordingly.

Making Balls.

6 Men required to each kettle; 2 to cast the balls, 1 to extract and roll, and 3 to trim them.

TOOLS AND UTENSILS. 1 *Iron kettle*, fixed in a furnace as before described—2 *iron ladles*, 0.10 in. thick, 3.5 in. diameter, with a lip on the left side and a handle 18 in. long a little bent—1 *bench*, of 4 in. plank—6 *moulds*, (brass,) with double rows for 6 or 8 balls on each side, or for 8 balls and 15 buckshot; placed on the bench—1 *mallet*—1 *double ball-gauge*; the diameter of one ring is 0.002 in. greater, that of the other 0.0015 less, than the true calibre of the ball—3 *nippers*; one arm is bent and fixed in the bench, the other is about 5 in. longer and has a wooden handle; the jaws are of steel, two inches wide, tempered and ground sharp; they may be so formed as to cut the gate according to the spherical surface of the ball. Under the jaws of the nippers is a hole in the bench, through which the balls fall into *boxes* placed to receive them—1 *rolling barrel*, 2 feet long and 1 foot diameter, made of hard thick staves, with but little bilge, and hooped with iron; it has a small scuttle in the bilge, with hinges and a hasp and staple; the barrel has a gudgeon in each head, and is turned by a crank in a frame to which a hopper may be attached. Instead of the rolling barrel, 2 strong *canvass bags* may be used; they should be 5 feet long and 16 in. in diameter, suspended horizontally by 4 cords attached to the joists of the building—1 *screen*, (sheet iron,) the holes of which are of the diameter of the largest calibre gauge; it is supported by gudgeons which turn in a frame, or in the tops of two stakes driven in the ground.

TO CAST THE BALLS. Weigh the lead; fill the kettle and cover it; as the lead melts add more, until it comes within 3 inches of the edge of the kettle; then cover it with a layer of powdered charcoal 1 in. thick; push the heat until paper in contact with the lead is inflamed by it; this requires from 1 to 2 hours.

Immerse the ladle and fill it about $\frac{3}{4}$ full of lead covered with charcoal, which is kept back with a piece of wood, in running the lead; fill all the moulds on one side, then turn them and fill the other side; the first castings are thrown back into the kettle, being imperfect from the moulds being cold; the diameter of some of the balls is verified from time to time, with the gauges; the moulds must be carefully cleaned when it is perceived that the lead sticks to them, and if any moulds give imperfect balls, they must be filled with copper.

Extract the balls and trim them; in cutting, the ball should be gently pressed

with the left fore-finger against the nippers, the gate being placed between the jaws.

TO SMOOTH THE BALLS. Put 100 lbs. of them into the rolling barrel, and roll them for 3 minutes; or 50 lbs. into a bag and shake it five minutes; then run them through the screen, putting in 50 lbs. at a time; those which remain on the screen are re-cast.

With the above force 30,000 to 35,000 musket balls are made in 11 or 12 hours.

With proper care in observing the instructions, 100 lbs. of lead will give from 96 to 98 lbs. of balls.

PACKING. Balls are packed in boxes made of 1 in. boards, 9 in. square inside and 6 in. deep, containing 100 lbs. of balls or buckshot; they should be marked on one end with the weight and kind of balls, the place and date of fabrication; the top is fastened with six 2 inch screws, and the boxes must be hooped for transportation.

Making Cartridges.

DIMENSIONS OF PAPER FOR CARTRIDGES.					SHEETS.		TRAPEZOIDS.			
					Length.	Breadth.	Height.	Long side.	Short side.	Number in one sheet.
					In.	In.	In.	In.	In.	
MUSKET.	{ Single ball, or ball and buckshot -				16.5	13	4.33	5.25	3	12
	{ Blank - - - - -				20	15	4	4.75	2.75	20
	{ 12 buckshot - - - - -				16.5	13	5.5	5	3	9
RIFLE,	{ Ball - - - - -				16.5	13	4	4.25	2.25	16
	{ Blank - - - - -				20	15	3	4.25	2.25	30
PISTOL,	{ Ball - - - - -				16.5	13	3.3	4.25	2.25	20
	{ Blank - - - - -				20	15	2.5	4.25	2.25	36

TO CUT THE PAPER. 1 Cutter, 1 assistant.

Implements. 1 *Cutting board*, 30 in. square—1 *pattern*, of hard wood or iron, of the dimensions of each of the papers—1 *rule*, of hard wood, 33 in. long, 1.5 in. wide and 0.5 in. thick, to cut by—2 *laboratory* (shoe) *knives*—2 *sand stones*, for sharpening knives on.

The paper is first cut into strips of a width equal to the length of a trapezoid, and then into trapezoids, by means of the patterns; cut about 12 sheets at a time.

TO MAKE THE CYLINDERS. 1 Master; 10 men to roll the cylinders; 1 to fill them, 4 to fold, 4 to bundle. Boys from 12 to 18 years of age may be advantageously employed.

Implements and utensils, for each workman for making cylinders : 2 *boxes* for the empty cylinders, made of $\frac{1}{2}$ in. boards ; interior dimensions, 20 in. long, 8 in. wide, and 5 in. high, without a cover ; they are placed upon the sides, facing each side of the cartridge table which is furnished with brackets to receive them, and also with a small enclosure or *locker* for balls, at the right hand of each workman—1 *spool of thread*, turning on a vertical iron spindle fixed in the table near the shot locker ; 1 lb. of thread is required for 10,000 single ball musket cartridges, being $8\frac{1}{2}$ inches to a cartridge—1 *choking string*, made by twisting together 4 or 5 cartridge threads ; fastened to the edge of the table, at the right hand of the workman—1 *pair of scissors*, to cut the thread—1 *former*, cylindrical, of hard wood, of the same diameter as the ball ; one end convex, the other concave, to receive $\frac{1}{3}$ of the ball ; length 6 or 7 inches.

Take the paper in the left hand, the former in the right ; lay the paper on the table, with the side perpendicular to the bases towards the workman, the broad end to the left ; place the former with its convex end at the broad end of the paper ; turn it so as to envelop it with the paper, then with the left hand laid flat upon the paper, roll all the paper upon the former ; seize it with the left hand, and with the choking string in the right hand, take one turn around the cylinder at about half an inch from the end, to which distance the end of the former is withdrawn ; hold the former firmly in the left hand, and draw gently upon the choking string, pressing at the same time, with the left fore-finger, upon the projecting end of the cylinder, thus folding it neatly down upon the end of the former. Having choked the cylinder, carry it to the right side, and with the twine in the right hand, take two turns and a half hitch firmly around the part that has been choked ; withdraw the former and introduce the ball, following it to the end of the cylinder with the former reversed ; raise the whole again, and with the same thread, (which is never cut until the cartridge is finished,) take two half hitches just upon the upper side of the ball, between it and the concave end of the former ; the operation is expedited by rolling the ball placed in the concave end of the former and choking the paper over it. Cut the thread and place the cartridge in the box which stands fronting the workman.

For ball and buckshot cartridges. Roll and choke the paper, put in 3 buckshot, follow them with the former, and take a half hitch of thread over them ; then insert the ball as before.

Buckshot cartridges have 4 tiers of 3 buckshot each, inserted like the first, with a half hitch between them, and finishing with a double hitch.

For common rifles, the ball is prepared by being enveloped in a square piece of fine *muslin*, or of soft thin *leather*, or of *bladder*, tied over it and leaving a projecting end about $\frac{1}{2}$ in. long, which, after being trimmed with scissors, and the

whole saturated with tallow, is introduced into the paper cylinder which is choked over it and fastened by two turns and a double hitch.

Cylinders for blank cartridges are made by folding down the paper over the concave end of the charger, touching the fold with a little paste, and pressing it on a ball imbedded in the table for that purpose.

TO FILL THE CYLINDERS. 1 Man to fill, 4 to fold, 4 to bundle.

Implements and utensils. 1 Large *copper pan* for powder.

1 *Charger* for each kind of cartridge, made of thin copper, with a handle at the top.

DIMENSIONS OF CHARGERS.	MUSKET.		MUSKETOON.		RIFLE.		CARBINE.		PISTOL.	
	Ball.	Blank.	Ball.	Blank.	Ball.	Blank.	Ball.	Blank.	Ball.	Blank.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Diameter, { top -	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
{ bottom -	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Height -	1.48	1.3	1.32	1.2	1.2	1.1	1.18	1.05	0.8	0.7

1 *Funnel*, copper, of the following interior dimensions :

		In.
Diameter of funnel,	superior -	1.75
	inferior -	0.5
Diameter of pipe -	-	0.5
Height of funnel -	-	1.
Length of pipe -	-	1.25

The funnel has a ring handle 0.6 in. diameter, or a handle of copper wire about 6 in. long.

1 *Folding box* for each calibre, made with only two sides; width equal to 5 times the diameter of the ball, height equal to twice that diameter. Two strips of wood nailed on the table will answer the same purpose.

Take the boxes full of cartridge cylinders to the table in the filling room; as they are filled, incline the cylinders over from the empty ones; when all in one box are full, fold the paper down over the powder by two rectangular folds, and place the cartridges before the men who are to bundle them.

BUNDLING. Put a wrapper in the folding box and place in it 2 tiers of 5 cartridges each, parallel to each other and to the short sides of the wrapper, the balls alternating; wrap the cartridges, whilst in the folding box, by folding the paper over them; tie them, first in the direction of the length, then of the breadth, with a bit of twine fastened in a single bow-knot. A bundle of musket cartridges is usually made with 5 single ball and 5 ball and buckshot cartridges.

DIMENSIONS OF BUNDLES.

KIND OF CARTRIDGE.			Length, (height of cartridge)	Breadth.	Thick- ness.	Mean weight of 100 bun- dles.
			In.	In.	In.	lbs.
Musket,	{	Ball - - -	2.37	3	1.3	77
		Buck and ball - -	2.55	3	1.3	94
		Buck shot - - -	2.75	3	1.3	92½
		Blank - - -	1.83	3	1.3	19
Musketoon,	{	Ball - - -	2.	3	1.3	71
		Buck and ball - -	2.18	3	1.3	87½
		Buck shot - - -	2.43	3	1.3	85½
		Blank - - -	1.39	3	1.3	13
Carbine ; musket calibre,	{	Ball - - -	1.81	3	1.3	69
		Buck and ball - -	2.	3	1.3	86
		Buck shot - - -	2.31	3	1.3	83½
		Blank - - -	1.32	3	1.3	12
Rifle,	{	Ball - - -	2.5	2.5	1.1	48
		Blank - - -	1.9	2.5	1.1	14¾
Carbine ; rifle calibre,	{	Ball - - -	2.1	2.5	1.1	44½
		Blank - - -	1.58	2.5	1.1	11¾
Pistol,	{	Ball - - -	1.68	2.5	1.1	40
		Blank - - -	1.12	2.5	1.1	7¾

Wrapping paper is but slightly sized, with a view to its being immersed, before using it, in a varnish made of bees-wax 4 lbs., linseed oil 1 gill, spirits of turpentine 2 galls., for the purpose of making the paper water proof.—See *Chapter 13*.

With the above mentioned force, 10,000 musket cartridges are made and bundled in 10 hours, being 1000 for each maker of cylinders.

Packing Cartridges.

Ball cartridges are packed in kegs or boxes to contain 1000 each. Blank cartridges may be packed in powder barrels.

DIMENSIONS OF PACKING BOXES FOR 1000 CARTRIDGES.

KIND.		Height.	Length.	Width.	Weight.	REMARKS.
		In.	In.	In.	lbs.	
Musket,	Ball - -	6.5	15.25	9.5	12	{ Will contain 1500 blank cartridges.
	Buck and ball	6.5	15.25	10.25	13	
	Buckshot -	6.5	15.25	11.	13.75	
Musketoen,	Ball - -	6.5	15.25	8.	10	Will contain 1750 blank.
	Buck and ball	6.5	15.25	8.75	11.3	
	Buckshot -	6.5	15.25	9.75	12.25	
Carbine, musket calibre.	Ball - -	6.5	15.25	7.25	9	Will contain 1750 blank.
	Buck and ball	6.5	15.25	8.	10	
	Buckshot -	6.5	15.25	9.25	11.75	
Rifle,	Ball - -	5.5	12.75	10.	11.3	{ Will contain 1250 rifle or 1500 carbine, blank.
	Blank - -	5.5	12.75	9.5	10.75	
Carbine, rifle cal.	Ball - -	5.5	12.75	8.5	9.62	Will contain 1500 blank.
Pistol,	Ball - -	5.5	12.75	6.75	7.62	

The boxes are made of 1 in. white pine boards, and are furnished with wooden brackets or handles nailed to the ends; the lids fastened with four $1\frac{3}{4}$ in. screws. They are painted olive color. The kegs or boxes should be lined with strong water proof paper, and the bundles of cartridges must be closely packed, so as not to shake in transportation. Each keg or box should be marked on one end with the number and kind of cartridges; on the inside of the cover, the place and date of fabrication.

AMMUNITION FOR CANNON.—*Plate 13.**Charges of Powder for Field Service.*

KIND.	FOR GUNS.		FOR HOWITZERS.		
	12 pdr.	6 pdr.	24 pdr.	12 pdr.	Mountain.
	lbs.	lbs.	lbs.	lbs.	lbs.
For shot and shells -	$2\frac{1}{2}$	$1\frac{1}{4}$	2 and $2\frac{1}{2}$	1 and $1\frac{1}{4}$	{ $\frac{1}{2}$
For canisters and spherical case shot }	2	1	2	1	

These charges are contained in cartridge bags—The small charge for a howitzer is attached to a block of wood called a *cartridge block*—The shot, shell or canister is attached to a block of wood called a *sabot*—For *guns*, the shot or canister is united to the charge, forming a *round of fixed ammunition*—For

howitzers, the shells and canisters are separate from the charge, except for the mountain howitzer for which the ammunition is fixed as for guns.

Cartridge Bags.

The best materials for cartridge bags are wildbore, serge, and bombazette. The stuff should be composed entirely of wool, free from any mixture of thread or cotton, and sufficiently fine to prevent the powder from sifting through; that which is not twilled is to be preferred. Flannel is used when the other materials cannot be conveniently obtained.

MAKING CARTRIDGE BAGS. A cartridge bag is made of a *rectangle* which forms the cylinder and a circular piece which forms the *bottom*.

DIMENSIONS.	FOR GUNS.		FOR HOWITZERS.			REMARKS.
	12 pdr.	6 pdr.	24 pdr.	12 pdr.	Mountain.	
	In.	In.	In.	In.	In.	
Length of rectangle	14.2	11.4	14.2	11.4	10.42	1 in. allowed for the seams.
Height	10.	7.25	6.	6.	5.	$\frac{1}{2}$ in. do. do.
Diameter of bottom	5.25	4.37	5.25	4.37	4.	1 in. do. do.

1 Marker, 1 assistant and 1 cutter.

2 *Tables—patterns*, of hard, well seasoned wood, or sheet steel, for the rectangles and bottoms—*scissors—french chalk*, or *colored crayons*, to mark with. The length of the rectangle (the development of the cylinder) should be taken in the direction of the length of the stuff, as it does not stretch in that direction.

The marker and his assistant spread a piece of stuff on a table, and with the patterns, trace out the rectangles and bottoms; the cutter follows and cuts them out with scissors.

Sewing. The bags are sewed with woollen yarn, with not more than 12 stitches to 1 in.; they are stitched within $\frac{1}{2}$ in. of each edge and the two edges of the seam are turned down on the same side and basted, to prevent the powder from sifting through; the edges of the bottom are basted down upon the sides. Bags for fixed ammunition are sewed to within 3 in. of the mouth, for 12 pdrs.; to within 2.75 in., for 6 pdrs.; all others, up to the mouth.

Cartridge bags when filled should pass through the small shot gauge of their

calibre; those used for patterns should be thus verified. The empty bags should be measured by laying the bag, flattened out, between two marks on a table, showing the width of the pattern bag; a variation of 0.1 in. greater or less is allowed. Reject those sewed with too large stitches.

Bags for immediate use at the place where they are made, and for blank cartridges, may be formed by sewing together two rectangular pieces with semicircular ends; the stuff is marked, for cutting and sewing, with stamps of the following dimensions:

CALIBRES.				12 pdr.	6 pdr.
				In.	In.
Stamps	{ for cutting,	Width	- - - - -	7.6	6.
		Length, including semicircular ends	- - - - -	10.5	8.5
	{ for sewing,	Width	- - - - -	6.6	5.2
		Length, including semicircular ends	- - - - -	10.	8.

These stamps are made of 1 in. boards of the dimensions of the cutting stamp, with a handle in the middle of one side; to the edges of the board is fastened a strip of tin or copper projecting about $\frac{3}{4}$ in. on the side opposite to the handle; another strip is inserted in like manner in a groove parallel to the edges of the board, at the distance indicated for the sewing stamp; the edges of these strips are made rough, to retain the chalk or paste used for marking.

Cartridge bags are preserved from moths by being packed with pounded camphor and black pepper, or dipped in water with arsenic dissolved in it. They may be preserved from moisture by being enveloped in water proof paper, as above recommended for cartridges for small arms.

Cartridge Blocks.—Plate 13.

DIMENSIONS.				HOWITZERS.	
				24	12
				In.	In.
Height	-	-	-	1.	1.4
Diameter	-	-	-	4.15	3.2
Distance from the middle of the groove to the bottom of					
the block	-	-	-	0.4	0.4
Width of the groove	-	-	-	0.3	0.3
Depth of do.	-	-	-	0.15	0.15

Sabots—Plate 13.

DIMENSIONS.	SABOTS.									
	For Shot and Shells.					For Canisters.				
	Guns.		Howitzers.			Guns.		Howitzers.		
	12	6	24	12	Mtn.	12	6	24	12	Mtn.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Whole height	2.	1.55	2.4	2.	2.7	2.25	2.25	4.45	3.25	3.75
Diameter { at top	4.35	3.35	5.3	4.27	4.2	4.52	3.58	5.72	4.52	4.52
{ at bottom	4.15	3.2	4.6	3.6	2.8	4.15	3.2	4.6	3.6	2.8
{ at bottom of conical part	—	—	—	—	3.24	—	—	—	—	3.24
Cavity for the ball { depth	1.5	1.0	1.5	1.3	1.3	—	—	—	—	—
{ radius of curv.	2.26	1.8	2.83	2.26	2.26	—	—	—	—	—
Distance from middle of lower groove to bottom of sabot	0.4	0.4	—	—	0.55	0.4	0.4	—	—	0.55
Distance between centres of grooves	—	—	—	—	—	0.8	0.8	—	—	—
Width of the grooves	0.3	0.3	—	—	0.3	0.3	0.3	—	—	0.3
Depth of the grooves	0.15	0.15	—	—	0.15	0.15	0.15	—	—	0.15
Height of the cylindrical part	—	—	—	—	—	0.5	0.5	0.7	0.5	0.5
Diameter of do. do.	—	—	—	—	—	4.47	3.53	5.63	4.47	4.47
Distance between the holes for handles	—	—	1.5	1.5	—	—	—	2.3	1.8	—
Diameter of the holes	—	—	0.25	0.25	—	—	—	0.25	0.25	—

The wood for sabots and cartridge blocks should be straight grained and well seasoned; *poplar*, or some other close grained wood is generally used—Sabots for shells and for howitzer canisters may be made of *elm* or *walnut*. The handle is of *strong twine*. The sabots are verified with a gauge showing their principal dimensions; the diameters and the cavity of each sabot should be accurately verified.

1 Turner, with 1 helper to rough out, can make, in 10 hours, 130 sabots for shot; 120, for 12 pdr. shells; 90, for 24 pdr. shells.

Straps.

Straps are made of sheet tin; they are cut with shears and straightened with a wooden mallet, upon a block of lead.

For shot, there are two straps crossing at right angles, one passing through a slit in the middle of the other. For shells, there are four straps soldered to a ring of tin, or fastened to it by cutting 4 slits in the ring, into which the upper ends of the strap are hooked and turned down on the inside of the ring.

DIMENSIONS.		FOR SHOT.		FOR SHELLS.		
		12-pdr.	6-pdr.	24-pdr.	12-pdr.	6-pdr.
		In.	In.	In.	In.	In.
STRAPS.	{ Width -	0.45	0.35	0.55	0.45	0.35
	{ Length -	12.75	10.	9.30	7.50	5.
RINGS.	{ Exterior -	-	-	2.25	2.25	2.25
Diameter,	{ Interior -	-	-	1.15	1.15	1.15

Strapping Shot and Shells.

UTENSILS AND IMPLEMENTS. 1 *Bench*—2 *pans*, containing *nails* 0.55 in. long, with strong flat heads 0.2 in. diameter—*boxes* and *barrels*, for straps and sabots—4 *hammers*, for strapping—1 *common hammer*—4 *punches*—*shot gauges*, of each calibre—1 *gauge* for each calibre, 0.04 in. greater than the largest shot gauge, through which the shot should pass after it is strapped—*tow* or *rags*, for wiping balls—1 *wheelbarrow*—1 *tarpaulin*, if the shop has not a plank floor.

A helper knocks off the scales from the balls with a hammer, wipes them, and gauges them both before and after they are strapped. The workman inserts the roughest part of the shot in the cavity of the sabot, and strikes a few blows on the bottom of the sabot to make the shot enter; he can tell by the sound if the shot touches the bottom of the cavity; if it does not touch, he tries another sabot; with the edge of the hammer he bends one end of the strap which is not slit into the groove of the sabot, punches and nails it; he fastens the other end in the same manner, cutting off the superfluous length; he then nails the other strap, and with his hammer sets them both in, close to the ball, at the top of the sabot. The sabots for field howitzers having no groove, each strap is fastened by 1 nail on the side and 2 under the bottom of the sabot. Two men can strap, in 10 hours, 130, 12 pdr. or 6 pdr. shot, or 75 shells, cutting the tin from the sheet.

If tin or sheet iron cannot be procured, straps may be made of *strong canvass*, 1 in. wide, sewed at the point of crossing. The part of the ball which is to be inserted in the sabot is dipped in glue; the straps are also glued to the ball; the ends are doubled into the groove and secured by two nails in each end. Another method is to wrap round the ball a band of canvass 1 in. wide, one half of which is glued to the ball, the other to the sabot; or, the shot may be kept in place by merely tying the cartridge bag over the top of it.

Cylinders and Caps.

For the greater security of ammunition, the cartridges for guns are covered with paper cylinders and caps, and those for howitzers, with caps. The cap is drawn off at the moment of inserting the charge, and in serving *guns* it may be placed over the shot to diminish the windage. A cylinder and a cap are formed together by folding the paper over a *former*, which allows a lap of about 0.75 in. for pasting. The requisite length for the cylinder is cut off from the smaller end; the rest forms the cap which is *choked* at the end from which the cylinder is cut.

DIMENSIONS.		FOR GUNS.		FOR HOWITZERS.	
		12	6	24	12
		In.	In.	In.	In.
Paper for cylinders and caps.	Length -	14.	12.	9.	8.
	Breadth -	14.4	11.6	14.4	11.6
Height of cylinder.	For large charge -	4.5	3.5	Same as for 12 pdr. gun.	Same as for 6 pdr. gun.
	For small charge -	4.	3.		
Formers for cylinders and caps.	Length (exclusive of handles) -	15.	13.		
	Width at upper end.	6.71	5.25		
	Width at lower end.	6.6	5.17		
	Thickness -	0.15	0.15		
Cylindrical formers for choking caps.	Length -	10.	10	Same as for 12 pdr. gun.	Same as for 6 pdr. gun.
	Diameter -	4.3	3.3		

The choking formers should be bored through the axis with a $\frac{1}{2}$ in. hole, to facilitate drawing off the cap; the edges of one end are rounded.

Fixing Ammunition.

IMPLEMENTS AND UTENSILS: *Barrels* for powder—1 *funnel*—1 *set of powder measures*—1 *straight edge*, to strike the measures with—*barrels*—*tubs*, formed of barrels sawed in two, or *boxes* for the cartridge bags—2 *taraulins*—2 *benches*—12 *choking sticks*, 6 with holes in them and 6 slit—6 *knives*—6 *handbarrows*, with four legs and a box, and *taraulins* to cover them—*calibre gauges*, for the cartridge bags and for fixed ammunition; they may be made of wood—6 *stools*—1 *wheelbarrow*—1 *mallet*—1 *copper chisel*—1 *copper drift* or a *copper wrench*, to open powder barrels.

For dimensions of powder measures—See page 115.

FIXING SHOT. The bags should be filled in the small magazine or filling

room, and carried, after being shaken and gauged, to the finishing room. One of the gaugers takes a filled bag with one hand, squeezing the bag upon the powder; he strikes with the other hand on the top and bottom of the bag, twisting the mouth of the bag down upon the powder at the same time; he then tries it with the small gauge through which it should pass with not more than 0.25 in. play; should it not do this, the bag is emptied and rejected. These bags, filled and gauged, are placed upright in a tub or box, and carried by the gaugers into the finishing room where the men are placed in pairs, sitting astride on a bench, facing each other. One of them opens a bag and levels the powder, the other inserts the sabot of a strapped shot square upon the powder and draws up the end of the bag over the shot; the first man passes about 4 feet of twine through the pierced stick, and makes two turns and a double hitch with the end at the top of the sabot; he makes a knot in the end of the twine, inserts it into the slit in the other choking stick, and tightens the double hitch by rolling the twine on the sticks and bearing upon the sabot; he then takes out the end of the twine from the slit, ties it in a hard knot which he tightens with the assistance of the choking stick, and cuts the twine off near the knot. The second man turns down the mouth of the bag over the sabot and the first makes a similar tie in the groove; he makes another tie below the sabot, the twine being lodged between it and the powder, to prevent the latter from sifting in between the bag and the sabot; he then runs the paper cylinder over the cartridge and sabot, leaving about 2 inches of the end of the cartridge uncovered, and he makes a tie, similar to the others, in the groove of the sabot. He now holds the shot in the left hand and examines it, striking the sabot with the right hand, if necessary, to bring it straight; if the shot is properly fixed, the sabot and the bag will be on the same axis; the seams should be between two straps, and the knots should be neither on the seams nor on the straps.

The assistants pass the cartridges through the large gauge, which is 0.04 in. larger than the large gauge for the shot. If the size is correct, they put on the paper cap, lay the cartridges on their sides in the box of the hand-barrow, and carry them to the magazine. Those which will not pass through the gauge are handed back to the fixers who cut the strings and put them up anew.

Canisters for guns are fixed in the same manner, except that the first tie is made in the upper groove of the sabot; the cylinder is tied in the lower groove. The caps must be cut somewhat shorter than those for shot cartridges.

For the mountain howitzer, the shells must be charged before the cartridges are attached.

For other howitzer cartridges: the cartridge block is inserted on the powder and a tie made in the groove; the mouth of the bag is then turned down, and

another tie made between the cartridge block and the powder ; the superfluous part of the bag is cut off, and the cartridge covered with its cap, leaving a part of the cartridge block uncovered.

When the shot is attached to the sabot by a single band of canvass, or when it is placed in the sabot without any strap, the cartridge bag is drawn over it and tied on top ; for this purpose, the bag should have an additional length of from $2\frac{1}{2}$ to 3 inches.

When sabots cannot be obtained, place upon the powder a layer of tow about 0.2 in. thick, forming a bed for the shot ; tie the bag over the shot and around the tow ; the bag requires to be 1 inch longer than for strapped shot.

FIXED AMMUNITION.	FOR GUNS.		FOR HOWITZERS.		
	12	6	24	12	Mount'n
DIMENSIONS.	In.	In.	In.	In.	In.
Height of charge of powder, including cartridge blocks for 24 & 12-pdr. howitzers { Large charge	5.	4.	5.	4.	2.25
{ Small charge	4.	3.2	5.	4.5	-
Height of strapped shot or shell - - -	5.02	4.13	6.58	5.22	5.87
Height of canister with sabot - - -	7.75	6.75	9.55	7.15	6.85
Height of a round of { Shot or shell - - -	10.02	8.13	-	-	8.12
fixed ammunition. { Canister - - -	11.75	9.95	-	-	9.10
WEIGHTS.	lbs.	lbs.	lbs.	lbs.	lbs.
Charge of powder, including bag and cartridge block { Large charge	2.56	1.3	2.56	1.3	} 0.53
{ Small charge	2.06	1.05	2.3	1.25	
Shot or shell strapped, (shell empty, without fuze) - - - - -	13	6.45	16.78	8.70	8.83
Canister, with sabot - - - - -	13.5	6.8	21	9.64	10.2
Spherical case shot, strapped and loaded -	10.87	5.43	20.56	10.93	11.0
Round of fixed { Shot or shell - - -	15.56	7.75	-	-	9.36
ammunition. { Canister - - -	15.56	7.85	-	-	10.73

Packing Field Ammunition.

Packing boxes, for field ammunition, are made of well seasoned white pine plank 1.25 in. thick, dovetailed together. The top of the box is fastened with six 2-in. wood screws ; the box has a rope handle attached to a bracket, on each end ; it should be painted on the outside, and marked on one end with the kind of ammunition ; the place and date of fabrication are marked on the inside of the cover.

PACKING BOXES FOR FIELD AMMUNITION.

KIND OF AMMUNITION.				INTERIOR DIMENSIONS OF BOX.			No. of rounds in a box.	WEIGHT.	
				Length.	Width.	Depth.		Of ammunition.	Of box packed.
				In.	In.	In.		lbs.	lbs.
FOR HOWITZERS. FOR GUNS.	12-PDR.	Round shot fixed - - -	-	21	9.25	9.5	8	125	148
		Canisters, fixed - - -	-	24	9.25	9.5	8	125	150
		Spherical case, with cartridges -	-	21	9.25	9.5	8	104	128
	6-PDR.	Round shot, fixed - - -	-	25.5	8.5	7.75	14	109	132
		Canisters, fixed - - -	-	25.5	10.25	7.75	14	110	135
		Spherical case, with cartridges -	-	25.5	8.5	7.75	14	91	114
	24-PDR.	Shells, with cartridges - - -	-	17.5	11.5	11.75	6	115	140
		Canisters, with cartridges - - -	-	28.5	9.75	10.75	6	140	175
		Spherical case, with cartridges -	-	17.5	11.5	11.75	6	137	163
	12-PDR.	Shells, with cartridges - - -	-	27.5	9.25	9.25	12	120	146
		Canisters, with cartridges - - -	-	29	9.25	9.75	12	131	164
		Spherical case, with cartridges -	-	27.5	9.25	9.25	12	146	172
	MOUNTAIN.	Shells, fixed - - -	-	27.5	9.25	9.25	12	128	159
		Canisters, fixed - - -	-	27.5	9.25	9.25	12	112	145

Manner of packing.

12 Pdr. shot and canisters, fixed: Laid in 2 tiers, lengthwise of the box, the shot against the ends.

6 Pdr. shot and canisters, fixed: In 2 tiers across the box, the shot of the lower tier alternating with the cartridges at each side, and those of the upper tier resting on those of the lower.

24 Pdr. and 12 pdr. howitzer shells, strapped: Shells with fuze holes down; cartridges, bursters, &c. laid on top.

24 Pdr. howitzer canisters: 5 canisters across the box in the lower tier; 1 on top near the middle of the box; the cartridges, &c. on each side of the upper canister.

12 Pdr. howitzer canisters: 8 canisters laid lengthwise in two rows in the lower tier; two at each end on top; the cartridges placed on end between the top canister.

24 Pdr. and 12 pdr. spherical case shot: Placed with the fuze holes down; the cartridges, &c. on top of the sabots.

6 Pdr. spherical case shot: Laid on their sides, in 2 rows across the box, the sabots in the middle; cartridges, &c., on top.

Mountain howitzer canisters and shells, fixed: Placed upright, the balls down; the shells resting on strips placed lengthwise of the box, to prevent the fuzes from touching the bottom.

In each box there should be packed a due proportion of slow match, quick match, portfires, tubes, fuzes and bursting charges, according to the nature of the ammunition. See Chap. 11.

The boxes should be lined with strong paper, and the ammunition must be securely packed in tow rammed tight between the shot, cartridges, &c. so as to prevent shaking.

Strapping Shells for Sea Coast Howitzers.

Shells for sea coast howitzers are strapped to sabots similar to those for field howitzers, except that the sabot has a band of tin to which the straps are soldered, and the rope handle is inserted in two loops of tin attached to the straps, near the fuze hole.

Dimensions of Sabot, &c., for an 8 In. Shell.

									In.
SABOT.	{	Whole length	-	-	-	-	-	-	3.5
		Diameter,	{ at top	-	-	-	-	-	7.53
			{ at bottom	-	-	-	-	-	6.41
		Cavity for the shell,	{ Depth	-	-	-	-	-	2.2
			{ Radius of curvature	-	-	-	-	-	3.93
		Depth of the groove for tin band	-	-	-	-	-	0.10	
		Width of do. do.	-	-	-	-	-	0.75	
STRAPS.	{	Distance from the middle of the groove to the bottom of the sabot	-	-	-	-	-	2.83	
		Width	-	-	-	-	-	0.75	
RING.	{	Length	-	-	-	-	-	13.	
		Exterior diameter	-	-	-	-	-	3.	
RING.	{	Interior diameter	-	-	-	-	-	1.3	
		Length of the band for the sabot	-	-	-	-	-	23.4	

Canisters.

For the dimensions of *Canister Shot*, see *Chapter 2*.

If it becomes necessary to use shot of other sizes, take such as will chamber well in the cylinder, and vary the number of shot so as to make up, as nearly as practicable, the required weight; shot of different diameters may be used for the outer and inner rows.

Canisters for shot consist of a tin cylinder with a bottom of wrought or cast iron, and a sheet iron cover; the tin is 0.02 in. to 0.025 in. thick; the cylinder is formed on a mandril and soldered; the bottoms are of cast iron for guns larger than 12 pdr. and for the 8 in. howitzer; of boiler plate, for other guns and howitzers.

A *Canister for field service*, is attached to a sabot on the top of which the iron bottom is placed, and to which the tin cylinder is fastened with 6 or 8 nails 0.5 in. to 0.75 in. long; the top of the cylinder is cut into strips 0.4 in. long, and turned down over the sheet iron cover.

A *Canister for siege and garrison service*, is made by turning one end of the cylinder over the iron bottom, from 0.25 in. to 0.38 in. wide, according to the calibre; the other end is cut into strips 0.5 in. long, to turn down on the cover when the canister is filled; the cover for these canisters has a handle 3.75 in. long by 1.75 in. wide, made of iron wire 0.15 in. thick, fastened to the cover by a strap of sheet iron, 2 in. long 1.75 in. wide, secured by two rivets 0.15 in. thick.

DIMENSIONS OF CANISTERS.	FOR GUNS.				FOR HOWITZERS.			
	SIEGE AND GARRISON.		FIELD.		SIEGE.	FIELD.		
	42	32	24	18	12	6	24	12
	In.	In.	In.	In.	In.	In.	In.	In.
Tin for the cylinder	21.5	20.	18.3	16.7	14.40	11.5	18.3	14.4
Height, including folds	9.6	9.	8.1	7.55	6.4	5.4	6.3	4.8
Interior diam. of cylinder, (diameter of mandril)	6.78	6.19	5.63	5.12	4.47	3.53	5.63	4.47
Diameter of plates for bottom and cover	6.73	6.14	5.58	5.07	4.42	3.48	5.58	4.42
Thickness of bottom plate	*0.5	*0.5	*0.5	*0.5	0.25	0.25	0.25	0.25
Thickness of sheet iron cover	0.1	0.1	0.1	0.1	0.07	0.07	0.1	0.07
Number of tiers of shot	4.	4.	4	4	4	4	4	4
Number of shot in each of 3 lower tiers	7.	7.	7	7	7	7	12	12
Number of shot in 4th tier	6.	6.	6	6	6	6	12	12
Whole number of shot	27.	27	27	27	27	27	48	48
Height of finished canister, (including sabot,)	8.7	8.1	7.35	6.8	.75	6.75	9.55	7.15
Weight of finished canister. lbs.	48.	37	29	23	13.5	6.8	21	9.64

* Cast iron.

A variation of 0.05 in. more or less is allowed in the diameter of the iron bottom.

The exterior diameter of each canister must be verified with the maximum shot gauge of the calibre, and the interior, with a cylinder of a diameter 0.02 in. less than that given in the table, which should enter the canister, otherwise it is rejected.

FILLING CANISTERS. Place the canister upright on a bench, supported (if it be fixed to a sabot,) by a small box or frame; insert the iron bottom and place it square on the edge of the canister or on the sabot; put in a tier of balls, fill the interstices with dry sifted saw dust, pack it with a pointed stick so that the balls will hold by themselves, and throw out the loose saw dust; place another tier of balls and proceed in the same manner until the canister is filled; cover the upper tier with saw dust; put on the cover and on it place one of the iron bottoms furnished with a handle, and strike it with a small mallet in order to compress the saw dust; then remove this bottom and turn down the slit pieces of the canister over the cover, with a hammer. When the canister is finished, verify its diameter with the maximum shot gauge of the same calibre.

FIXING CANISTERS. As before remarked, canisters for field *guns* and for the mountain howitzer are fixed to the charge in the same manner as round shot and shells, except that the first tie over the cartridge bag is made in the upper groove of the sabot; those for the 24-pdr. and 12-pdr. howitzers are not fixed and are therefore furnished with handles of strong twine attached to the sabots, like those of the shells for the same pieces.

Canisters for immediate use may be made of pasteboard. On a cylindrical former 0.5 in. less in diameter than the calibre of the piece, roll a sheet of pasteboard 0.08 in. thick, and of such a length as just to meet round the cylinder; to the end of the former apply a wooden canister bottom 1.5 in. thick; take a half hitch of twine 0.08 in. thick round the paper and nail it to the edge of the wooden bottom; then wrap the paper closely with twine to the required height of the canister; take out the former and fill the canister, covering the balls with another block of wood on which the upper edge of the pasteboard is turned down and nailed.

Grape.

For the dimensions of *Grape Shot*, see Chapter 2.

A **STAND OF GRAPE**, for siege, garrison, or sea coast service, consists of 9 shot, put together by means of 2 cast iron plates, 2 rings and 1 pin and nut.—
See Plate 14.

DIMENSIONS.	8 in.	42	32	24	18	12
	In.	In.	In.	In.	In.	In.
Diameter of plates - - -	7.85	6.83	6.24	5.68	5.17	4.52
Thickness of plates - - -	0.6	0.6	0.5	0.5	0.4	0.4
Interior diameter of rings - -	6.55	5.73	5.16	4.75	4.26	3.8
Diameter of round iron for rings and pin -	0.6	0.5	0.5	0.38	0.38	0.32
Length of pin, including tapped part - -	10.45	9.25	8.7	8.	7.18	6.12
Height of stand, between the outsides of the plates	9.85	8.75	8.2	7.5	6.8	5.8
WEIGHTS.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Plates - - - - -	13.6	10.2	8.	6.75	4.56	3.44
Pin, nut and rings - - - - -	4.75	2.8	2.5	1.81	1.12	0.69
Stand, complete - - - - -	74.5	51.25	39.75	30.61	22.15	14.84

The square of the nut is 2 diameters of the pin; its thickness, 1 diameter. The head of the pin is countersunk flush with the bottom of the lower plate and it has a *slot* to prevent the pin from turning when the nut is screwed on. Each plate has on the inside 3 beds for the shot, of a depth equal to half the thickness of the plate; they are made in the form of a spherical segment the curvature of which is the same as that of the shot; their centres are on equidistant radii, midway between the edge of the pin hole and that of the plate. In the upper plate are 2 holes 0.25 in. diameter, placed opposite to each other at 0.5 in. from the edge of the plate, to receive a rope handle.

For sea coast howitzers, the stand of grape must be attached to a conical sabot. The sabot for the 8 in. howitzer is 4.25 in. long, 7.85 in. diameter at the large end and 6.4 in. at the small end. The sabot may be fastened to the lower plate with screws, or the pin may be made long enough to pass through it; or else the sabot may be inserted into the piece separately from the stand of grape.

QUILTING GRAPE. If it be necessary to use shot of irregular sizes, which cannot be put up in the manner above described, the stand of grape may be made by enclosing the shot in a sack of strong canvass, (sail cloth,) attached to a *stool* formed of a *plate* of cast iron with a *pin* fixed in the centre of it; the sack is quilted over with marline 0.1 in. thick, to make the stand compact and firm.

The plate of the stool is 1 in. thick, with the edges rounded; the diameter of the lower surface of the plate for any calibre is the same as that given in the above table, that of the upper surface is 0.15 less; in the edge of the plate is a groove 0.5 wide and 0.3 in. deep. The pin has a head or button at the upper end, 0.5 in thick.

DIMENSIONS.	42	32	24	18	12
	In.	In.	In.	In.	In.
Diameter of shot, to chamber 5 in					
a tier - - - -	2.47	2.26	2.05	1.85	1.62
Diameter of pin - - -	1.64	1.55	1.4	1.26	1.15
Diameter of button - -	2.	1.8	1.7	1.5	1.3

The length of the pin and of the sack will depend on the size of the shot made use of; this size should be such that the shot may chamber not more than 6 in a tier, and the number of tiers in a stand must be regulated so that the whole weight for any calibre shall not exceed that given in the foregoing table, nor be less than the weight of the round shot for the same calibre. For the large calibres, the bottom only of the stool need be of cast iron, with a hole to receive a pin of hard wood; the weight of the stool will thus be reduced and the number of shot in the stand may be proportionally increased.

To make a stand of grape. Sew up the canvass with strong twine in the form required for a bag of the size of the bottom of the stool; put one end of this bag around the bottom of the stool, with the seam outside, the canvass being on the side opposite to the pin; tie it strongly with twine in the groove and turn it over the bottom, so that the pin shall be within the sack and the twine concealed; insert the shot in regular tiers; gather the mouth of the sack round the pin, run the needle through it, take two turns of the marline round the sack under the button of the pin and fasten it; then pass the needle diagonally to the bottom, following the course of the shot; run the marline through the canvass at the bottom and carry it up in another direction to the top, take a turn round the pin and carry it to the bottom as before, taking a half hitch on the marline when the courses cross each other; continue this quilting until each shot is enclosed in a separate mesh.

Cartridges for Siege, Garrison, and Sea Coast service.

The ordinary service charge of powder for heavy guns is *one-fourth* the weight of the shot, but the charge varies according to circumstances, from *one-half* the weight of the shot (for a breaching battery) to *one-fifth* or *one-sixth* of that weight, for firing double shot or hot shot, and still less, for ricochet firing. The charges for mortars and howitzers vary according to the required time of flight of the shell.

The length of any charge is easily deduced from the following table of the medium height or length of a charge of 1 lb. of cannon powder packed in a cartridge cylinder of each calibre.

CALIBRES.		42	32	24	18	12	9	6
		In.	In.	In.	In.	In.	In.	In.
Diameter of cartridge cylinder	- -	6.5	5.9	5.35	4.9	4.2	3.8	3.3
Height of a charge of 1 lb.	- - -	0.83	1.	1.23	1.47	2.	2.47	3.2

For the height of a *cartridge*, due allowance must be made for the form of the bottom of the bag.

Cartridge bags for siege, garrison, and sea coast cannon are made of paper cylinders with flannel bottoms; the bottoms are made of two pieces cut in a semi-circular form with a straight part which is sewed to the cylinder.

DIMENSIONS.		42	32	24	18	12
		In.	In.	In.	In.	In.
Paper for cylinders.	{ Length, including the fold	27.	26.	23.	21.	19.
	{ Width, (development of cylinder)	22.	20.	18.5	17.	14.5
	{ Width of the fold	9.	9.	8.	7.	6.
Formers for cylinders.	{ Width	10.	9.1	8.2	7.5	6.4
	{ Length	20.	18.	16.	15.	14.
	{ Thickness	0.2	0.2	0.2	0.2	0.2
Stamps for marking the flannel.	{ For cutting.	{ Width	11.2	10.3	9.4	8.7
		{ Length	7.1	6.6	6.2	5.85
	{ For sewing.	{ Width	10.2	9.3	8.4	7.7
		{ Length	6.6	6.15	5.7	5.35
						4.8

MAKING THE BAGS. *The utensils and implements* are similar to those used in making up field ammunition; to which may be added a *comb punch and mallet*, for piercing the paper cylinders to facilitate the sewing.

Cylinders for 42 and 32 pounders require $1\frac{1}{2}$ sheets of paper No. 6, which are pasted together with a lap of about 1.5 in. The fold is cut off from the length of the paper and is pasted on the other part to within 1.5 in. from the end; when dry, the paper is folded on the former, and the lap pasted. The two halves of the flannel bottom having been sewed up to within 1.5 in. of the straight sides, these are inserted between the two thicknesses of paper, when the cylinder is dry, and they are sewed with woollen yarn.

Cartridge bags for proving cannon, are made in the same manner as other cartridge bags of like calibre, but they should be of the full diameter of the bore.

PACKING. The flannel bottoms are folded into the cylinders and the bags pressed flat; they are bundled in packages of 50 each, the ends alternating;

each package is enveloped by two strips of paper tied with two turns of twine. If necessary, the flannel may be treated as beforementioned to preserve it from moths. Each bag and each bundle should be marked with the calibre of the piece for which it is designed.

FILLING. These bags are filled as they are required for service, the charge being weighed or measured, as may be most convenient. When filled, the end is folded down about $\frac{3}{4}$ in. wide, and this fold is rolled on itself down to the powder, and the part which projects beyond the cylinder turned in on the top of it.

Cartridge bags for mortars, are made in a similar manner with those for guns, their dimensions corresponding to those of the chamber. For mortars with conical chambers the papers for cylinders are cut in the form of a trapezoid of which the ends are arcs of circles, and they are rolled on a conical former.

Cartridge bags for the sea coast howitzers and for small mortars, may be made entirely of serge or flannel. In the howitzer the cartridge should always fill the chamber, for which purpose a *cartridge block* is placed in the bag when firing with charges less than that which fills the chamber. The lengths of these blocks are, for the 8 in. howitzer, in the proportion of 1 in. for every pound which is taken off from the full charge.

In making flannel bags for heavy guns the same stamps may be used as for marking the flannel bottoms for paper cylinders, the straight sides being cut of the required length for the bag.

In case of need, cartridge bags for heavy cannon may be made entirely of paper; the bottom is circular and one end of the cylinder is cut into slits about 1 in. long, which are pasted to the paper bottom on a cylindrical former; the former must be bored through its axis to facilitate drawing off the bag. These bags are apt to leave paper burning in the gun, on which account those with flannel bottoms are preferable, especially in firing with small charges.

Cartridge bags for firing hot shot are made by putting one paper bag within another, or they may be made of parchment. In the latter case, care must be taken that the parchment is free from holes; it is moistened by dipping 20 or 25 rectangles in water, and taking them out immediately; they are then pressed, and folded when half dry. The bags when filled are tied with twine.

For ricochet firing, or other occasions when very small charges are required, a cartridge bag for a piece of an inferior calibre may be used; or else, after the charge is poured into the bag, place on it another bag filled with hay, pressing it with the hands to reduce its diameter; after having shaken this bag down and rolled and flattened the empty part of the two bags, tie them with woollen yarn, like a bundle of musket cartridges, placing the knot on top.

They consist of a ring of serge or rope yarn, about 0.7 in. thick, loosely twisted ; the size of the ring being a little greater than the diameter of the bore, in order that it may fit tight. These wads are attached with twine to the straps, or to the shot or shells, and in using them, the rammer head is hollowed out if necessary, to receive the top of the ball.

Filling Shells.

CHARGES FOR SHELLS.		13 in.	10 in.	8 in.	24	12
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Charge - -	{ of the shell filled with powder	11	5	2 9	1	0 8
	{ required to burst the shell -	6	2	1	0 8	0 4
	{ required to blow out the fuze	0 6	0 5	0 4	0 2	0 1
Ordinary service charge.	{ Cannon powder - - -	7	3	1 12	0 12	0 6
	{ Incendiary match, or other					
	{ composition - - -	0 8	0 6	0 6	0 4	-

1 Man to fill, 1 helper.

MATERIALS. *Cannon powder—incendiary match—pieces of fire stone 3 in. long, or other incendiary composition—loaded fuzes—tow.*

IMPLEMENTS AND UTENSILS. *1 Pair of shell hooks—1 handspike—2 hand hammers—2 scrapers, (pieces of sword blade)—2 tow hooks—2 pairs of pincers—rags—1 chisel and 1 mallet, to clean the shells and break up any hard substance that may be found in the interior—2 searchers, for sounding cavities—shell gauges—1 grate, to dry the shells on—1 fuze saw—1 gimlet—a ring of rope, or a hollow block—1 funnel—powder measures—1 tub, or vessel for powder—2 baskets, for the composition and fuzes—1 rasp—1 fuze setter and 1 mallet.*

TO CHARGE A SHELL. Clean the shell inside and out ; gauge it ; see that it has no holes or fissures deep enough to cause its rejection ; that the fuze hole is well reamed, and that there are no flaws around it on the inside ; if the shell is wet, heat it slightly and let it cool slowly.

Cut the fuze at the proper length, according to the range, by resting it in a groove made in the block, the saw running in a cut made for it ; or bore the fuze through with a gimlet, perpendicularly to the axis, at the proper length.

Place the shell on the block or ring of rope ; pour in the powder and introduce the incendiary composition ; try the fuze, which should enter $\frac{3}{4}$ of its length ; cover the head of the fuze with tow, and drive it with the fuze setter and mallet, so that the head of the fuze shall project not more than 0.2 in. in shells for guns and howitzers, and 0.4 in. to 0.75 in. in shells for mortars.

Shells are generally filled and the fuzes driven in the field, or in the battery magazines, as they are required. For field service the bursting charges are put up in small flannel bags.

Charging shells in a laboratory. The solid part of the fuze only is cut off, or a hole is bored through the fuze, at the bottom of the composition.

To work rapidly and with order, in charging many shells at a time, employ 2 men to charge, 1 to mark, and 3 to help.

In addition to the objects before mentioned, have *white chalk—a kettle—kit composition*, for covering the fuze caps—*balls of twine—circles of serge*, for caps—*1 pair of scissors—1 earthen pan*.

The marker and his helpers place the shells in 2 rows, one charger puts in the powder which is carried in a tub by two of the helpers; the marker holds the funnel and marks the shell with chalk; another charger, with the third helper, introduces the incendiary composition and puts in the fuzes. When all the shells are charged, the 2 chargers and 2 helpers drive the fuzes. If the fuze is capped with paper only, or if the cap is torn, the marker and the third helper cover it with the serge cap, which is held down by one and tied by the other in a half hitch and a hard knot. The kit is then melted, the kettle carefully wiped, and brought near to the shells, and each man dips in a fuze to such a depth that the shell shall be covered with kit to the distance of 1 in. around the fuze.

For the mountain howitzer, the shells must be loaded and the fuzes driven before attaching the cartridge.

Spherical Case Shot.

CHARGES.				8 in.	42	32	24	18	12	6
Cannon powder	-	oz.		15	8	7	6	5	4½	2½
Musket balls,	Number	-		486	306	216	144	108	72	36
	Weight	-		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight of the shot loaded	-	-		27	17	12	8	6	4	2
				57	38	28	20	15¼	10½	5¼

After inspecting and cleaning the shot, attach them to sabots in the same manner as shells for field howitzers; put in the balls and the bursting charge, shaking the shell at the same time, and lastly insert a strand of quick match 6 in. long. For short ranges, cut the fuze and drive it in the same manner as

for a common shell. When long fuzes are required, a few of the balls must be emptied out of the shell, and as much of the powder reserved as will nearly fill a flannel bag of the size of the fuze hole and the length of the cavity of the shell; take a cylindrical piece of hard wood and insert it into the fuze hole, enveloped in such a bag as just described; turn up the shell and shake it until the stick bears on the bottom; then turn the shell back, withdraw the stick, pour the reserved part of the charge into the flannel bag and drive the fuze on the powder which will soon give way through the bag.

The fuzes for spherical case shot may be cut to the length suited to the longest range required, and the time of burning may be regulated in the field, by boring out the composition from the top of the fuze with a fuze auger, graduated according to the range, the priming of mealed powder in the cup being retained and inserted again into the fuze. Ordinarily, the shot is filled with balls alone, and the fuze hole is stopped with a cork or a soft wooden plug; the bursting charge is inserted and the fuze driven in the field, at the moment of using the shot; for this purpose the bursting charges are put up in flannel bags, and the fuzes are cut to various lengths and distinctly marked.

MILITARY FIREWORKS.

Slow Match.

PREPARATION. Slow match is made of hemp, flax, or cotton rope, about 0.6 in. diameter made with 3 strands, slightly twisted. Cotton rope well twisted forms a good match without any preparation.

To prepare hemp or flax rope: boil it 10 minutes in water holding in solution 1-20th of its weight of sugar of lead; or let it remain in the *cold* solution until it is thoroughly saturated—run it through the hands, to take the water from it—twist it hard by attaching one end to the hook of a twisting winch, and putting a stick in a loop at a convenient distance for twisting—smooth it by rubbing it smartly with coarse mats, hair cloth, or cuttings of buff leather, commencing at the winch and rubbing always in the same direction, until the diameter of the rope is reduced 0.1 in. and until the tension and hardness are even—stretch it on poles or on a fence to dry, and put it up in neat coils of 25 yards each.

Match thus prepared burns 4 inches in an hour. Cotton match burns 4½ inches in an hour.

If sugar of lead cannot be procured, the rope may be simply leached—for this purpose, it is put into a leach-tub, and steeped in pure water for 12 hours—this water is then drawn off and replaced by ley prepared in a boiler with a quantity of ashes equal to half the weight of the rope, to which 5 per cent. of quick lime

is added—this ley, with the ashes, is put, after being warmed, into the hopper of the tub, and when it has run through and remained some time in the tub, it is drawn off, heated again and poured back on the ashes—this operation is several times repeated in the course of 24 hours, which is the time required for the rope to be well leached—after being taken out and twisted with sticks, it is steeped for 5 minutes in hot water, being stirred at the same time, and the operation is finished as before. Match prepared in this manner burns 5 inches in an hour.

By treating bad match or old rope with sugar of lead, very good match may be made.

Match made of hemp rope weighs $5\frac{1}{4}$ oz. to the yard; of cotton rope, $3\frac{3}{4}$ oz.

PACKING. Slow match is packed in tight casks or boxes. A cask 40 in. high, 24 in. diameter (weighing 60 lbs.) contains 150 lbs. of hemp match, or 170 of cotton match.

Dimensions of a box to hold 200 lbs. hemp or 220 lbs. cotton match; 44 in. long, 28 in. wide, 18 in. deep—weight 87 lbs.—It is made of boards 1 in. thick, ends $1\frac{1}{4}$ in.—it has corner pieces of hard wood 2.25 in. square. The casks and boxes should be marked with the kind and quantity of match, place and date of fabrication.

Quick Match.

Take cotton yarn, such as is used for candle wick, of such a size (generally 4 strands) that when doubled and twisted in the fingers, it may be 0.07 in. in diameter—wind it into a loose ball of convenient size, (say 1 lb., which will measure 1000 yards,) and steep it in gummed brandy or whiskey, until the cotton is thoroughly soaked—in a wooden bowl or copper pan, put a layer about $\frac{1}{4}$ in. deep, of paste made of mealed powder and gummed spirits, of the consistence of flour paste—on this, spread a coil of the cotton by unrolling the ball and distributing it equally on the surface of the paste until there are 5 or 6 yarns over one another—put another layer of the paste, and proceed in this manner until the bowl is full, taking care not to entangle the strands; the last layer of paste should be a little deeper than the others—after the cotton has been 3 or 4 hours in the bowl, wind it on a reel, making it pass through a funnel filled with the paste, and taking care that the several turns of yarn do not touch each other—before it is dry, dredge it with mealed powder—let it dry slowly, then cut it off from the reel and put it in bundles. The gum should be first dissolved in the smallest possible quantity of hot water or vinegar, and afterwards mixed with spirits.

Match thus prepared should be hard and stiff, and the composition should hold firmly on; 1 yard burns, in the open air, 13 seconds.

1000 yards of quick match require 1 lb. of cotton yarn, 8 lbs. of mealed powder, $1\frac{1}{4}$ gallons of spirits, and $2\frac{1}{2}$ oz. of gum arabic. Weight when dried, 9 lbs.

By using *vinegar*, a match is made which burns less rapidly in the proportion of 4 to 5, and with pure water, in the ratio of 4 to 6. *Alcohol* makes a quicker match, but it cannot be gummed, and the composition does not stick.

A slow kind of match is made by adding sulphur to the mealed powder; with one-sixth of sulphur, 1 yard of match burns 22 seconds; with one-fifth, 33 seconds; with one-third, 53 seconds; with one-half, 162 seconds.

Quick match enclosed in tubes burns more rapidly than in the open air, and more so in proportion as the tubes are smaller. To communicate fire very rapidly, it is enclosed in paper tubes called *leaders*.

Priming Tubes.

		In.
MAKING TUBES. Dimensions.—Length	-	3.25
	Exterior diam.	
	{ at top	0.17
	{ at bottom	0.14
Interior diam.	{ at top	0.12
	{ at bottom	0.09
Exterior diam. of cup	{ at top	0.75
	{ at bottom	0.70
Depth of cup	{ exterior	0.25
	{ interior	0.21

Weight of tubes, empty—65 to a pound.

Metal for tubes—50 lbs. Banca tin

50 lbs. Lead

$1\frac{1}{4}$ lbs. Antimony

} for 6000 tubes.

The metal is melted in an iron pan, placed in the oven of a stove, and the moulds are kept heated, at the same time, so that their temperature may be high enough to scorch dry shavings. During the casting, the moulds should be smoked occasionally with rosin, or pine knots, to prevent the tubes from sticking. Six moulds should be used in casting, and they should not be cooled by wetting them. When not in use, the moulds must be kept well oiled and free from rust.

The tubes are drawn by means of a lever fixed into the work bench, and when the spindle withdraws, leaving the tube in the mould, a small screw is inserted into the tube, which, by being gently tapped with a hammer, loosens the tube and withdraws it.

Tubes are afterwards *cupped* by running them through a groove, over which a plane is passed, turning in the edges of the cup.

CHARGING. Tubes are filled with mealed powder made liquid by spirits of wine, which is injected into them with a *tube injector* holding one quart. The cup being filled with the same paste, a small brass wire, (No. 22,) is run through the tube and withdrawn after the composition is dry.

A paper cap is placed over the cup and twisted tightly around the tube, under the cup.

Composition to fill 1000 tubes :

2½ lbs. mealed powder.

2 quarts of whiskey, or spirits of wine.

Weight of tubes filled—56 to a pound.

QUILL TUBES. Priming tubes may be made also of quills; for this purpose the barrel of the quill is cut off at both ends, the largest end is slit into 7 pieces 0.5 in. long, which are bent outwards at right angles—fine woolen yarn is then woven into these slits, like basket work—the tube is filled and finished as before.

These tubes are preferable for service on ship-board, or in casemates or blockhouses, as there is no danger from the fragments blown out of the vent, which there may be with metallic tubes.

Tubes are tied up in bundles of 10, wrapped in paper.

Portfires.

MAKING THE CASES. *Formers* for portfire cases are made of steel, turned smooth, 22 in. long, and 0.5 in. diameter, with a hole 0.2 in. diameter through one end, for the purpose of drawing it from the case. The length of the case is 18 inches; exterior diameter 0.65 in.; interior diameter 0.5 in. One sheet of paper, No 4, makes two cases, and each case weighs 1 oz. The case is rolled hard with a hand rolling board, the sheet being pasted after one turn around the former.

DRIVING PORTFIRES. *Portfire moulds* are made of brass; they are 18 inches long, with a bore 0.65 in. diameter; the mould consists of two parts, 0.4 in. thick at top, and 0.6 in. at bottom, which are held together by a socket at bottom and by 4 strong bands.

Three *drifts* are used for driving portfires; they are made of steel, with brass tips, 0.5 in. long, upon the lower end. These drifts are 22 in., 15 in. and 10 in. long, and of a diameter 0.1 in. less than the interior diameter of the case. Four spiral grooves are cut upon the surface of the drifts, making one half of a revolution in 22 inches; the grooves are 0.15 in. wide, and 0.05 in. deep. The handles

of the drifts are 6 inches long and 0.75 in. diameter, with the head enlarged to 1.25 in.

Mallets for driving portfires are turned of hard wood, and weigh one pound.

Put the case in the mould and drive on the rings—insert a small *funnel* in the top of the case—pass the long drift through the funnel to the bottom of the mould—fill the funnel with composition and strike the drift about three blows every second, raising the drift about half an inch with the fingers of the left hand, between the blows. In this way the composition finds its way around the sides and through the grooves of the drift to the bottom, and is uniformly and compactly driven. The shorter drifts are used, as the case is filled. A man can drive 120 portfires in ten hours.

Portfires should not be primed with mealed powder. Before commencing the driving, a piece of paper should be pushed with the long drift, to the bottom of the case, and after the portfire is driven, the top of the case should be turned in and beaten down; thus both ends of the composition are secured.

Composition for 100 portfires :

13 lbs. nitre.

4½ " sulphur.

2½ " mealed powder.

Total, 20 lbs.

The portfires made with this composition burn 11 minutes.

The composition must be intimately mixed, by grinding with a muller on the mealing table, rubbing it through the hands, and passing it through a sieve, re-grinding the coarse parts that remain, and adding them.

Portfires may be driven in a cylinder of sheet copper or tin, supported in a hole in a block of hard wood; but as they cannot be driven so hard in this way, the proportion of mealed powder in the composition should be reduced to 1½ lb., in order that the portfire may not burn too fast.

INTERIOR DIMENSIONS OF BOXES FOR PORTFIRES.						100	200
						In.	In.
Length	-	-	-	-	-	18	18
Width	-	-	-	-	-	9.1	9.1
Depth	-	-	-	-	-	5.1	10.1
Weight, packed,	-	-	-	-	lbs.	38	70

The boxes are made of white pine boards 0.75 in. thick, the sides dovetailed together, and the top fastened with six $1\frac{1}{4}$ in. screws, the heads countersunk and covered with putty. They should be lined with water proof paper, and painted with one coat of olive color—marked on one end with the number and kind of contents, and the year of fabrication.

Fuzes.—Plate 13.

Fuzes are made of beech, ash, or linden, seasoned and free from knots. They are bored in the lathe and the exterior is graduated into inches and tenths, (commencing at the bottom of the cup,) by means of a steel gauge applied to it in the lathe. A turner, with 1 helper to rough out, makes in 10 hours, from 50 to 100 fuzes, according to the size.

DIMENSIONS, &c.					13 in.	10 in.	8 in. 42 pdr. and 32 pdr.	24 pdr. and 18 pdr.	12 pdr.	6 pdr.
					In.	In.	In.	In.	In.	In.
Diameter of fuze	{ at upper end - - -				1.85	1.7	1.25	0.95	0.95	0.95
	{ at lower end of 1st cone - - -				1.65	1.55	1.15	0.85	0.85	0.85
	{ lower end of fuze - - -				1.25	1.	0.9	0.7	0.7	0.7
Diameter of cup	{ at the top - - -				1.25	1.	0.75	0.55	0.55	0.55
	{ at the bottom - - -				0.9	0.8	0.6	0.45	0.45	0.45
Diameter of the bore	-	-	-	-	0.4	0.3	0.3	0.25	0.25	0.25
Length of 1st cone	-	-	-	-	2.8	2.25	1.25	0.85	0.75	0.75
Depth of the cup	-	-	-	-	0.6	0.5	0.4	0.35	0.35	0.35
Thickness of wood at the bottom of the fuze	-	-	-	-	1.2	0.9	0.9	0.75	0.75	0.75
Length of composition	-	-	-	-	9.	8.	5.	4.	3.	2.75
Whole length of fuze	-	-	-	-	10.8	9.4	6.3	5.1	4.1	3.85
Length of 1st drift	{ exclusive of the handles	{	{	{	9.	8.	8.	4.	4.	4.
Length of 2d drift					4.5	4.	4.	2.	2.	2.
Diameter of drifts	-	-	-	-	0.36	0.27	0.27	0.22	0.22	0.22
					lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Weight of composition for 100 fuzes	-	-	-	-	8	4	$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{8}$	1
Weight of 100 fuzes, complete	-	-	-	-	54	33	16	8	$5\frac{1}{8}$	5

COMPOSITIONS FOR FUZES.

No.	Nitre.	Sulphur.	Mealed powder.	Time of burning 1 inch.	REMARKS.
1	2	1	3	3.8 sec.	May be used in fuzes for 10 in. and 8 in. mortars, light.
2	2	1	$2\frac{1}{4}$	5. sec.	May be used in fuzes for 13 in. and 10 in. mortars, heavy.
3	-	-	1	2.2 sec.	May be used in fuzes for 8 in. howitzer and all smaller fuzes.

The composition must be well pulverized, thoroughly mixed with the hands and sifted. As the time of burning will vary a little according to the quality of the materials used, (especially of the mealed powder,) a few trials should be made to determine the exact composition in each case.

DRIVING. The articles necessary for driving fuzes are: *Blocks* with holes of the size of the fuze—*mallets*—*steel drifts*, shod with copper—*copper ladles*, to contain sufficient composition to make 1 diameter of the bore in height when driven—*copper pans*—*quick match*—*mealed powder*.

In driving fuzes, be careful to put in equal quantities of composition each time, by passing a drift over the ladle, to take off the composition along the edges; keep the strokes as regular as possible, giving always the same number and with the same force to each ladle full of composition. The pan with the composition must not be placed on the driving block, as the sulphur would collect together, and would separate from the rest of the composition.

13 in., 10 in and 8 in. fuzes are driven with mallets that weigh 1 lb.; smaller fuzes, with mallets weighing $\frac{3}{4}$ lb. and $\frac{1}{2}$ lb.; 21 blows, in volleys of 3, are given to every ladleful of composition, in fuzes over 24 pdr., the drift being raised after each volley; 15 blows to each ladleful, in smaller fuzes.

1 man, in 10 hours, can drive 50 13-in., 80 8-in., 120 to 150 smaller fuzes.

Fuzes must always be driven to the same height, for which purpose the last drift must be marked. They are primed by laying two strands of quick match, 2 in. long, across the top of the composition, crossing each other at right angles; this match is confined by driving mealed powder upon it, with the same force as is applied to a ladleful of composition. The space left in the bore of the fuze, for the quick match and mealed powder, is about 0.2 in. The quick match being coiled into the cup of the fuze, the cup is filled with mealed powder moistened with spirits of wine or strong whiskey; when dry, it is covered with a small piece of paper, over which is pasted a cap of strong, water proof paper, marked with the number of seconds the fuze burns to the inch. For preservation and transportation, the fuze is capped with parchment, linen or serge tied on, and the head of it is dipped in kit. Fuzes are packed with tow, in boxes.

Fuzes may be driven with *blind fire composition*, which will not discover the flight of a shell in the night:

<i>Compositions:</i>		
Mealed powder.	Sifted wood ashes.	
1	6 parts,	4 parts.
2	16 "	9 $\frac{1}{2}$ "

One ladleful of the common fuze composition, or of mealed powder, must be driven in the top of these fuzes, with the quick match.

PERCUSSION PRIMERS.

Percussion primers for cannon and small arms are made of fulminating powder, mixed with a portion of gunpowder or some of its components, to give more flame and to lessen the violence of the explosion.

FULMINATING POWDER. *Fulminating mercury* and *chlorate of potash* are used for making primers; the latter has the effect of rapidly corroding iron; it may be obtained sufficiently pure from the druggists.

Fulminating mercury, or Howard's mercury, is composed of 74.65 peroxide of mercury and 25.35 cyanic acid; it detonates violently and with flame, by percussion, by friction, or by heat at 370° .

To prepare it: Dissolve 100 grains of mercury in $1\frac{1}{2}$ oz. of nitric acid, (specific gravity 1,333,) at a heat of 200° ; for this purpose, the mercury and acid may be put into a matrass or a Florence flask, and set in water of the proper temperature—when the effervescence has ceased and the liquid is cold, pour the solution into another matrass or flask, containing 2 oz. of pure alcohol; the flask should be large enough to contain 4 or 5 times the quantity of liquid which is put into it—stir the mixture, and heat it to the same degree as before, until a brisk effervescence takes place and thick white fumes arise—then remove the flask from the heat and let it remain without shaking, until the effervescence ceases, or until brownish yellow fumes come over, when a precipitate of fulminating mercury will be found at the bottom. When the liquor is cool, decant it and wash the precipitate. It should be kept in glass and in a moist state, to avoid accidents. When required for use, lay it on filtering paper and dry it *slowly*, at a heat not greater than 100° , or by exposure for two or three days to the air, in a well ventilated room.

Care should be taken not to inhale the fumes which arise during the first effervescence.

Percussion Primers for Cannon.

COMPOSITION; $\frac{1}{4}$ of fulminating mercury and $\frac{3}{4}$ of the following composition:

	oz.
Chlorate of potash	6
Sulphur	$1\frac{3}{4}$
Gunpowder	1
Antimony	$\frac{1}{2}$

To prepare this composition: Grind the chlorate of potash on a marble slab, with a little water; add the antimony and rub them well together, with water enough to make a stiff paste; then add the sulphur and the gunpowder suc-

cessively, and mix the whole thoroughly. The composition must be kept in glass or tin; when *dry* it explodes by percussion.

To make the primers: Add the fulminating mercury to the above composition in a moist state, and mix them together, on glass or marble, with a wooden or ivory spatula; mould this paste into lozenges, 0.4 in. diameter and 0.04 in. thick; put the lozenges between two circular pieces of musket cartridge paper 0.8 in. in diameter, which are united by isinglass glue and pressed firmly together; dry them and cut the paper with a circular cutter 0.6 in. in diameter.

Coat the primers with mastic varnish, or a solution of sealing wax in spirits of wine, or with other water proof varnish; keep them in glass bottles.

The cup of a metallic or quill tube may also be used to contain the fulminating composition, the barrel of the tube being charged with rifle powder.

OTHER COMPOSITIONS FOR PRIMERS.	1	2	3	4
Fulminating mercury	100	100	100	100
Saltpetre	60	45.5	51.1	-
Sulphur	-	14.5	-	-
Charcoal	-	-	7.9	-
Gunpowder	-	-	-	60

No. 1 is a white powder, commonly used for percussion caps for small arms.

Percussion Caps for Small Arms.

These caps being readily obtained by purchase, it is not considered necessary to describe here the manner of fabricating them. The best kind are the *split caps*, charged with the white composition of fulminating mercury and saltpetre, mentioned in the preceding table. Chlorate of potash is not used, on account of its corrosive effects.

The sizes of these caps are designated by numbers.

FIREWORKS FOR SIGNALS, LIGHTS, AND INCENDIARY PURPOSES.

All dry compositions must be well mixed, first by the hands, and then by being passed several times through a fine hair sieve, in order that the ingredients may be thoroughly incorporated. In mixing compositions which require the use of fire, the greatest precautions are necessary, particularly for those in which gunpowder enters. The dry parts of the composition may, generally, be mixed together first, and put by degrees into the kettle when the other ingredients are fluid, being well stirred all the time. When the dry ingredients are very inflammable, the kettle must not only be taken off from the fire, but the bottom of it must be dipped in water, to prevent the possibility of accidents.

Signal Rockets.

IMPLEMENTS. *Formers*, for rolling the cases on—*rolling bench*—*callipers*, for measuring the diameter of the case—3 *hollow drifts*, bored to admit the spindle of the mould—1 *solid drift*—*former* for the cone—*former* for the pot—*mould and spindle*—*charging ladle*—*mallets*—*knives*—*scissors*—*gimlets*, for piercing the clay heads—*press* and *crank*, for rolling the cases—*choking machine*.

The dimensions of moulds, implements, and rockets are proportioned to the diameter of the orifice of the mould, or the exterior diameter of the rocket. The usual sizes are 1.5 in. and 2 in.

Height of the base of the mould,	-	1	diameter of the orifice.
Height of the mould,	-	$6\frac{1}{2}$	"
Exterior diameter of the mould,	-	$1\frac{1}{2}$	"
Height of the spindle,	-	$3\frac{1}{2}$	"
Nipple,	-	$\frac{1}{2}$	"
Length of the screw of the spindle	}	1	"
which passes through the foot of the mould,			
Thickness of the	{	1	"
spindle			
	{	$\frac{1}{3}$	"
Thickness of the			
nipple	{	$\frac{1}{3}$	"
	{	$\frac{2}{3}$	"

Thickness of the base equal to its height.

Moulds for rockets are cast in one piece and bored to the proper calibre.

Spindles, with their nipples, are made of cast steel; the base and screw, of iron.

Drifts and *formers* are made of brass, or of hard seasoned wood. The wooden drifts are tipped with copper $\frac{1}{8}$ of an inch thick, which is let into the wood without exceeding the size of the drift—the first drift is pierced so as to receive the whole length of the spindle; the second to receive $\frac{2}{3}$; the third $\frac{1}{3}$; the fourth solid. Each drift has a handle 4 or 5 inches long, and somewhat larger than the body of the drift; the top strengthened by a band of copper. The diameter of the *former* for cases is $\frac{2}{3}$ that of the orifice of the mould—one end is pierced to receive the tap of a piece of the same diameter as the former, and $1\frac{2}{3}$ diam. long—the diameter of the tap or small part of this piece, which enters into the former, for choking the case, is $\frac{1}{3}$ of the interior diameter of the mould. The diameter of the *ladle* for charging a rocket is equal to the interior diameter of the rocket and the length $1\frac{1}{2}$ diam.—it holds as much composition as, when driven, will measure in height one-half of the interior diameter of the case.

Mallets for driving 1.5 in. and 2 in. rockets weigh about two and three pounds respectively.

Interior diameter of rocket case, - $\frac{2}{3}$ exterior diameter.

Height of former, - 10

Length { 1st drift without the handle, $5\frac{1}{2}$ “

2d drift do. - 4 “

3d drift do. - $2\frac{1}{2}$ “

4th drift do. - $1\frac{2}{3}$ “

former for pot, - $2\frac{1}{2}$ “

former for cone, - $1\frac{2}{3}$ “

former, - $\frac{2}{3}$ “

drift, - $\frac{3}{5}$ “

pot, - 1 “

base of cone, - $1\frac{2}{3}$ “

The former for cones has a handle 3 inches long in the centre of the base.

Making rocket cases. A sheet of paper No. 4 makes 2 strips for a 2 in. or an 1.5 in. rocket, by cutting it parallel to the short or the long side respectively. The former is first enveloped with a sheet of strong smooth paper which is pasted after the first turn, and rolled tight in the press; the other strips of paper are then rolled on the former in the same manner, until the case has attained the requisite size.

To choke the case. Wrap a piece of strong paper over it, at the joint in the former, to prevent the cord from chafing it; take a turn round it with the choking cord, and press on the treadle, turning the case at the same time, and draw-

ing out the small part of the former as the paper contracts; wrap the choke firmly with strong twine. Let the case dry slowly, and when perfectly dry, trim it to the proper length, so that the distances from the middle of the choke to the bottom and top of the case shall be equal to the distance from the bottom of the spindle to the bottom and top of the mould respectively.

COMPOSITIONS.	Nitre.	Sulphur.	Charcoal.	Steel filings.
1	16	4	6	4
2	10	2	3	—
3	8	2	3	—

DRIVING ROCKETS. The composition must be well mixed by passing it through fine sieves and by rubbing it in the hands; the charcoal, being the lightest ingredient, must be added after the nitre and sulphur have been mixed; steel filings or antimony should be added after the charcoal. Whilst driving the rocket, the composition must be frequently stirred to prevent the settling of these heavy materials to the bottom. The clay which is driven in the top is pierced with a gimlet to the composition; through this hole the fire communicates to the bursting charge in the pot which contains the ornaments.

To put the case in the mould. Place it with the choked end down, over the spindle, and settle it with a mallet until it rests on the base of the spindle; then set the mould over it and key it to the base.

To drive the rocket. The hollow drifts are first used, taking the shorter drifts as the case fills, until the composition reaches the top of the spindle; then drive 1 diam. in height with the solid drift, cover this with a patch of stiff paper cut to fit the case, and over this patch drive a wad $\frac{1}{3}$ diam. high, of clay, or of plaster of paris slightly moistened with water.

Rockets are sometimes driven solid throughout, and afterwards bored with a tap of the form of the spindle.

A rocket is primed with a piece of quick-match about 2 feet long, which is coiled in the bottom of the case, and covered with a cap of strong paper pasted down or tied in the choke.

The force to be employed in driving rockets depends on their size: A rocket $1\frac{1}{2}$ in. diam. receives 25 smart blows, and a 2 in., 30 blows of the mallet, on each ladleful of composition.

WEIGHT.						2 in.	1.5 in.
						oz.	oz.
Case ready for charging	-	-	-	-	-	9½	4
Case charged	-	-	-	-	-	16	8
Rocket finished	-	-	-	-	-	20	10

POTS FOR ROCKETS, are made of rocket paper; two or three turns of paper are rolled upon a former of the same diameter as the rocket, being well pasted, except the interior or first turn upon the former. The pot is two diameters long, and is secured in its place on the rocket by paste and an exterior covering of fine paper. The interior depth of the pot, when attached to the rocket, is one diameter and a half.

CONES, are made of rocket paper, which is cut into circular pieces equal in diameter to twice the length of the cone intended to be made; each piece being cut in half makes two cones. They are rolled upon the former, pasted, and dried for use. In applying the cone to the rocket, its base is cut to the same diameter as the exterior of the rocket on which it rests; it is then filled with tow, to enable it the better to resist the action of the air without much increasing its weight; it is confined in its position by another cone made of fine paper, about an inch longer than the interior cone; this outside cone must have its base cut in slips, which being well pasted, unite with the sides of the rocket or pot and firmly secure the interior cone; a narrow slip of fine paper is then pasted over the bottom of the exterior cone, as a finish to the head of the rocket.

STICKS FOR ROCKETS, are made of dry pine or other light wood; the length is $49\frac{1}{2}$ diameters, or 9 times the length of the case; the large end which is attached to the rocket is $\frac{1}{3}$ the exterior diameter square, diminishing to one half of that thickness at the lower end; in the large end, a groove is made of a length $\frac{2}{3}$ that of the rocket case, in which the rocket is tied; the end of the stick is beveled off, to present less resistance to the air; just below this bevel, and also opposite to the choke of the rocket, notches are cut out to receive the twine with which the rocket is fastened to the stick. The poise of rockets should be verified by balancing them on a knife edge. Those of an exterior diameter under $1\frac{1}{4}$ in. should be balanced at 3 diameters from the neck; those of a diameter between that and 2 in., at $2\frac{1}{2}$ diameters; and those of greater dimensions, at 2 diameters. All these dimensions and precautions should be strictly observed, for if the stick be too light, the rocket will not rise vertically, and if the stick be too long and heavy, it will rise slowly and not arrive at its proper height.

DECORATIONS FOR ROCKETS. The pots of rockets are charged with various

decorations, as *stars*, *serpents*, *gold rain*, *rain of fire*, *marrons*, *crackers*, &c., and with about half a charging ladleful of powder.

STARS are the most beautiful decorations of rockets. They are made by driving the composition, moistened with alcohol and a small quantity of gum arabic solution, in portfire moulds without any paper case, and with a moderate number of blows; they are cut into lengths of about $\frac{3}{4}$ of an inch and dredged with mealed powder. A more expeditious and better mode of making them is, to mould them in a brass cylinder of the diameter desired for the stars, and push them out with a rammer, cutting them into proper lengths as they are formed. Stars, after being dredged with mealed powder, must be dried in the shade. The gum arabic used in star composition is intended to give such consistency to the stars that the explosion of the head of the rocket may not break them in pieces and thereby destroy the effect.

COMPOSITIONS.	Nitre.	Sulphur.	Mealed powder.	Antimony.
1	16	8	3	—
2	16	7	4	—
3	16	8	4	1½

SERPENTS are driven in small cases made of rocket paper or playing cards, rolled over a former 0.4 inch in diameter and covered with two thicknesses of strong fine paper, the last turn of which is pasted. When dry, these cases are choked at one end, without being entirely closed, and are then charged about $\frac{2}{3}$ of their length with composition, by means of a small mallet, a drift and a block of wood with a hole bored in it, to receive nearly the whole length of the case. The case is choked over the composition, and the remainder of it is nearly filled with mealed powder upon which a small paper wad is placed; a clay head is then driven on it and the end of the case turned down, to secure it; the other end is opened with a punch and primed with priming paste, or a small strand of quick match. Serpents are placed perpendicularly in the pot, with the primed end downwards.

COMPOSITIONS.	Nitre.	Sulphur.	Mealed powder.	Charcoal.	Steel filings.
1	3	2	16	$\frac{1}{2}$	—
2	15	4	—	2½	—
3	16	2	4	6	—
4	16	4	4	2	6

GOLD RAIN, is made in the same manner as stars, observing to cut or mould the composition into pieces of equal size. The effect of this decoration is beautiful and it is less troublesome than serpents.

COMPOSITIONS.	Nitre.	Sulphur.	Mealed powder.	Charcoal.	Pulverized soot.	German black.	Dissolved gum.
1	$\frac{1}{2}$	$1\frac{1}{2}$	8	—	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
2	16	10	6	4	—	2	—
3	16	8	8	2	—	2	—

RAIN OF FIRE, is made with small cases 0.3 in. diameter and 2 in. long; two thicknesses of paper are sufficient for them. The end of the case is closed and it is charged and primed like that for a serpent, omitting the powder for a cracker.

Composition. Mealed powder 16—Charcoal 6. Another kind which shows in sparks is made of camphor 16 parts, nitre 8, mealed powder 8, tow 8. The composition is formed into a very liquid paste with gummed brandy; tow chopped fine is put into the paste, and rolled into small balls about the size of buck-shot; when they have imbibed sufficient composition, they are rolled in mealed powder and dried.

MARRONS, are cubes filled with grained powder, and enveloped with two or three layers of strong twine or marline; to give them more consistency they are dipped in kit; they are primed by punching a small hole in one corner and inserting quick match. They are made of strong pasteboard, cut into the form of a parallelogram whose sides are in the proportion of 3 to 5, divided by 4 cuts from each side extending $\frac{1}{3}$ of the width and at equal distances apart, which prepare the paper for folding into the form of a cube of the size of one of the small squares thus marked out.

PACKING ROCKETS. The sticks are tied up in bundles; the rocket case is wrapped with tow so as to be larger than the pot, the tow being confined with a piece of twine long enough to tie on the stick. The rockets are placed in a box on a bed of tow laid under the choke, and they are pressed closely together; tow is then carefully stuffed in between the heads of the rockets; each tier is also covered with tow.

Fire Stone.

COMPOSITIONS.	1	2	3	4	5
	lbs.	lbs.	lbs.	lbs.	lbs.
Saltpetre - - -	0.75	0.80	0.80	0.80	6.00
Mealed powder - -	2.50	1.60	0.80	1.60	-
Quick match - -	-	-	-	-	0.28
Regulus of antimony -	-	-	-	0.60	2.00
Cannon powder - -	-	-	0.80	-	0.50
Roll sulphur - -	3.00	3.20	3.20	3.20	7.00

IMPLEMENTS. 1 *Large iron kettle*—1 *covered box*, for composition—4 *long ladles*—1 *small ladle*, with a long handle—2 *spatulas*—1 *copper dipper*.

MANIPULATION. Weigh out the necessary quantity of nitre and spread it on a mealing table; sprinkle over it the antimony finely pulverized and sifted; mix them together with spatulas. Spread this mixture on the table and sprinkle over it the grain powder; mix them thoroughly, then take up the composition with a copper dipper and place it in the box, which must be kept carefully covered. Put the brimstone in the kettle over a gentle fire of coals; bring forward the box containing the composition, to within 4 or 5 yards of the fire; place 4 workmen around the kettle, with their ladles; a fifth takes charge of the composition; as soon as the sulphur is melted, he sprinkles about a teaspoonful of composition in it; if it does not inflame, he takes about $\frac{1}{8}$ of the composition and sprinkles it with great care into the kettle. During this operation two of the workmen stir the mixture constantly with ladles; two others stand by to relieve them when fatigued, that the stirring may not cease for a moment. By adding the composition the sulphur is partially cooled; as soon as it is again melted, add another $\frac{1}{8}$ of composition, and stir as before. Continue in this manner till all the composition is used, observing always to let the mixture melt before throwing in another ladleful. Cut the quick-match in pieces about an inch long, and mix it by handfuls into the composition, which is now become very thick and sticky; this is the most dangerous part of the operation, the workmen must therefore stir with greater diligence. As soon as the quick-match is thoroughly incorporated, the mixture must be poured out into a wooden vessel or mould prepared for the purpose. In 24 hours it will be hard and fit for use. A good effect is produced by putting a small stick of wood in the centre of the stick of fire stone, in order to facilitate its inflammation. Fire stone properly prepared has a bright metallic appearance.

Valenciennes Composition.

Nitre	-	-	50 parts
Sulphur	-	-	28 "
Antimony	-	-	18 "
Rosin	-	-	6 "

The composition is cast in cylindrical copper moulds 6 inches long, of a diameter to suit the shell in which it is to be used. It is used as an incendiary composition, in charging shells, and is inserted along with the bursting charge, in pieces as large as the shell will admit without interfering with the fuze.

Carcasses.

CALIBRE,	13-inch	10-inch	8-inch	42-pdr.	32-pdr.	24-pdr.	18-pdr.
	lbs.	lbs. oz.	lbs. oz.	lbs. oz.	lb. oz.	lb. oz.	lb. oz.
Weight of composition -	19	7 8	4 4	2 8	1 14.	1 10	1 1

COMPOSITION. A solution of equal parts of white turpentine and spirits of turpentine, incorporated with as much portfire composition as will give the whole a compressible consistency; the portfire composition must be previously mixed with a small quantity of finely chopped tow. When properly incorporated, this composition is compactly pressed into the carcass with a drift, so as to fill it entirely. Sticks of wood of about $\frac{1}{2}$ inch diameter are then inserted into each hole of the carcass, in such a manner as to meet in the centre of the composition, in order that, when they are withdrawn, as many holes shall remain in the composition, in the same direction; in every hole thus formed, insert three strands of quick-match of a length sufficient to allow of their being folded over the edge of the hole two or three inches; some dry portfire composition must then be pressed into the interstices, to keep the quick-match fast in its place. Carcasses may be filled with the above composition omitting the *tow*, or with *fire stone*, and the holes may be bored with a gunner's gimlet before the composition becomes hard. The quick match must be coiled into the holes and secured, until the carcass is wanted, by fastening a small cotton patch over the holes with kit.

Common shells may be loaded and used as carcasses in the following manner: The bursting charge is placed in the bottom of the shell in a flannel bag, over which carcass composition is driven until the shell is nearly filled; then insert 4 or 5 strands of quick-match which must be secured by driving more composition upon it. These shells, after burning as a carcass, explode.

Fire Balls.

Fire balls are projectiles of an oval shape filled with combustible composition; they are made of sacks of strong canvass, formed of several thicknesses sewed together. The composition is made compact by being driven with mauls and a strong wooden drift. When the ball is filled to one fourth of its height, a *tarred link* is put in, and on it a loaded shell. The bottom is formed of a piece of wrought iron made fast with cement. The sacks, when filled, are covered with a net work of strong twine or marline.

DIMENSIONS.						13-in.	10-in.	8-in.		
						In.	In.	In.		
Rectangle of canvass for the sack.	{	Length, including the seam				-	-	36.	27.	22.
		Height				-	-	26.	20.	15.5
		Width of seam				-	-	1.	1.	0.75
Rope.	{	For the 4 ribs	{	thickness	-	-	0.45	0.35	0.3	
				length of each	-	-	156.	96.	48.	
	{	For the net work	{	thickness	-	-	0.5	0.25	0.25	
				length	-	-	800.	600.	450.	
	{	For the handle	{	thickness	-	-	0.25	0.2	0.2	
				length	-	-	36.	36.	36.	
Height of composition.	{	Before inserting the tarred link				-	-	2.75	2.	2.
		Whole height				-	-	13.	10.	7.

COMPOSITIONS.	1	2	3	4	5	6	7	8	9
Hard turpentine - -	86	98	138	136	-	-	82	163	122
Pitch - - -	61	59	61	63	-	-	40	82	61
Mutton suet - -	33	24	33	28	-	-	16	33	33
Turpentine - -	8	8	8	7.5	-	-	10	20	15
Linseed oil - -	8	8	8	7.5	-	-	10	20	15
Grain powder - -	204	196	204	142	-	16	163	245	245
Tow - - -	16	16	16	46	-	-	9	23	22
Saltpetre - - -	-	11	-	-	151	151	-	-	-
Sulphur - - -	-	5	-	-	163	88	-	-	-
Mealed powder - -	-	-	-	-	151	-	-	-	-
Rosin - - -	-	-	-	-	49	-	-	-	-
Gummed brandy - -	-	-	-	-	82	-	-	-	-
Inflammable sawdust - -	-	-	-	-	-	18	-	-	-
Bees-wax - - -	-	-	-	-	11	-	-	-	-
Antimony - - -	-	-	-	-	44	-	-	-	-
Composition No. 6 - -	-	-	-	-	-	-	82	245	122

To prepare the inflammable sawdust: Boil sawdust or tanner's bark in a solution of nitre, using half as much nitre as sawdust—crude nitre or damaged

powder will answer—put in as much water only as will cover the nitre and sawdust and boil to dryness, stirring frequently ; then spread out the sawdust to become perfectly dry before being used.

For the compositions 1, 2, 3, 4, 7, 8, 9, melt the turpentine, pitch and tallow together ; add the linseed oil and liquid turpentine, and lute the door of the furnace ; pour in the powder and the other materials in succession ; finally, add the tow picked into small pieces.

The composition No. 5, called the *Dutch composition*, is dry. Grind the materials with mullers ; mix them with 1-500th of their weight of tow, and drive the composition in a sack made of three thicknesses of canvass, coated with a composition of 1 part of bees wax to one-half of turpentine.

The composition No. 6, called the *Austrian*, is also dry. Melt the wax, add the saltpetre and stir it till it melts ; pour the mixture on a table ; add in succession the sulphur, antimony, and sawdust, grinding them together with mullers ; mix the gunpowder with them, and charge the sack as before.

The compositions Nos. 5 and 6, give a very brilliant flame ; Nos. 7, 8 and 9, partly composed of them, are to be used in preference to the others.

One 13 in. and one 8 in. fire ball may be charged with 60 lbs. of the composition No. 9 ; one 10 in. ball, with 25 lbs. of No. 7 ; two 8 in., with 27 lbs. of No. 4 ; a 32 pdr. shell is put into a 13 in. fire ball ; a 24 pdr. shell, into a 10 in. ; a large grenade, into an 8 inch.

After having charged the fire ball to the height indicated in the foregoing table, put in a tarred link previously steeped in a mixture of pitch and tallow melted together, and on this put the shell, the fuze even with the bottom of the link ; the shell is kept down by a square piece of canvass tied to the ball ; finish filling the ball, and tie the sack over the composition.

Fire balls are dipped in a composition of equal parts of pitch and rosin. To prime them, two wooden pins are driven, whilst the composition is soft, into the upper part, in the direction of the centre. Before they are fired, these pins are removed, and fuzes or fuze composition driven into the holes.

The iron bottom is attached to the ball by the following cement :

	lbs.	oz.
Bees wax	-	3
Pitch	-	2
Rosin	-	1
Turpentine	-	1
Brick dust	-	9

The materials are melted successively over a slow fire, and the brick dust is stirred in last ; the iron bottom is filled about one-third full with the cement, and

the loaded end of the fire ball is inserted in it and left to cool. The ball is then wrapped with the net work, as before mentioned.

Light Balls.

Light balls are made in the same manner as fire balls, except that there is no shell in them, which is required in the fire ball to prevent its being approached for the purpose of extinguishing it.

Tarred Links. (Tourteaux.)

Are used for lighting up a rampart, or for incendiary purposes. They consist of coils of soft rope placed on top of each other and loosely tied together; the exterior diameter is 6 inches, the interior 3 inches. They may be made of pieces of slow match about 15 feet long; immerse them for 10 minutes in a composition of 1 pitch and 1-20th tallow, and shape them under water; when dry, plunge them in a composition of equal parts of pitch and rosin, and roll them in tow. In making them, the hands of the workmen should be covered with linseed oil.

A *link* takes from 1 lb. to 1½ lb. of composition and ½ lb. of tow. Two of them are put into a rampart grate, separated by shavings. They burn one hour in calm weather, half an hour in a high wind, and are not extinguished by rain. The grates are placed about 250 feet apart.

Other compositions. Links may be dipped twice in a composition of 2 pitch and 1 rosin; or, first in tar and then in the preceding composition; or in rosin alone; but they burn only half the time—or first, in 9 pitch, 2 tallow, 1 linseed oil, 1 turpentine; and then in the same, with the addition of ½ rosin.

Pitched Fascines.

Fagots of vine twigs or other very combustible wood, about 20 in. long and 4 in. in diameter, tied in three places with iron wire, may be treated in the same manner as *Links*, and used for the same purpose; their inflammability is increased by dipping the ends in melted fire stone.

Torches.

In a solution of equal parts of water and nitre, boil old rope or slow match, well beaten and untwisted; let it dry perfectly, and cut it in pieces about 4 feet long; tie three or four of these pieces around a piece of pine wood about 2 in. diameter and 4 feet long; cover the whole with a mixture of equal parts of sulphur and mealed powder, moistened with brandy; fill the intervals be-

tween the cords with a paste of 3 parts of sulphur and 1 of quick lime. When it is dry, cover the whole torch with the following composition:

Pitch	-	-	3 parts
Venice turpentine	-	3	"
Turpentine	-	$\frac{1}{2}$	"

Kit.

Composition : 9 rosin, 6 pitch, 6 beeswax, 1 tallow. To be melted together and poured into water; then worked with the hands until it becomes soft and pliable.

Incendiary Match.

Boil slow match in a saturated solution of nitre; let it dry; cut it into pieces, and plunge them into melted fire stone.

1 Yard of match requires about 1 lb. of fire stone.

Blue Lights.

Composition for 100 lights :

	lbs.	oz.
Saltpetre	9	10
Sulphur	2	6 $\frac{1}{2}$
Red orpiment	0	11

The ingredients are pulverized, rubbed between the hands and passed several times through a fine hair sieve; the brilliancy of the light depends on the purity and thorough incorporation of the materials.

The composition is pressed into a hemispherical cup about 2.5 in. diameter, made of well seasoned wood, (beech, linden, &c.,) with a stem or handle about the size of a 13-in. fuze. It is primed with a strand of quick match, and covered with paper which is pasted over the bottom of the cup.

STORAGE AND PRESERVATION OF AMMUNITION AND FIRE- WORKS.

Leaden balls, are generally kept in cellars, on account of their weight; the boxes should be kept as dry as possible, and so piled as to admit the circulation of air about them.

Flints, should be kept in cool, damp, and dark situations, generally in cellars; air, light, and heat seem to injure them; the occasional circulation of air is necessary, however, for the preservation of the boxes or barrels containing them.

Cartridges for small arms, are kept in magazines; the barrels or boxes being

piled 3 or 4 tiers high at most. If barrels or boxes are not at hand, lay the bundles flat on a tarpaulin and pile them 10 high.

Fixed ammunition for cannon. If not in boxes, it should be placed in piles formed of two parallel rows of cartridges, with the sabots together; in 4 tiers for 12-pdr., and 5 for 6-pdr.; chock the lower tier with strips of wood fastened with small nails; put a layer of tow 2 in. thick between the shot; let the piles rest on timbers, if there is no floor, and cover them with tarpaulins; have the place swept, and the cartridge bags brushed off. Leave a passage of 18 in. between the double rows, and keep them 2 feet from the walls.

Fixed ammunition should not be put into powder magazines, if it can be avoided; it should be kept in a dry place, above the ground floor if practicable; the store room should be always aired in fine weather; the piles should be taken down and made up again every six months at most, the bags examined and repaired, and the damaged cartridges broken up. A ticket on each pile should show the number and kind of cartridges, the additions to the pile, and the issues.

Canisters. Piled up like fixed ammunition, in 4 tiers for 24's and 18's; and 5, for 12's and 6's. Empty canisters in 10 or 12 tiers; the bottoms and covers separately.

Cartridge bags filled. Like fixed ammunition.

Paper cartridge bags. In bundles, packed in boxes or on shelves, in a dry place, with the precautions before indicated against worms and moths.

Loaded shells, should never be put into magazines, except from absolute necessity; powder is not well preserved in them. They should be piled on the ground floor of a secure building; on timbers, if the floor is not boarded; in 6 tiers at most; the fuzes of the lower tier in the vacant spaces between the shells; those of the other tiers turned downwards, like the fuze holes of empty shells; the pile should be covered with a tarpaulin.

Slow-match. In a dry place, such as a garret.

Quick-match. If not in boxes, it may be hung up in bundles, on ropes or pins, and covered with paper.

Priming tubes, Portfires, Fuzes, Signal Rockets. In safe and dry situations.

Fire balls. In a cool place, separated from each other by shavings or straw, if they are piled up.

Tarred Links. Strung on a rope and hung up; for transportation they are packed in barrels, with straw between the tiers.

Fascines and Torches. Packed like the preceding.

Fire stone and Incendiary Compositions should not be kept in large quantities.

Percussion primers, in cool, dry places, apart from gunpowder, ammunition, &c.; some cannon primers have exploded under circumstances which led to the opinion that their combustion was spontaneous. They should be carefully protected from rats, &c, by being enclosed in glass or tin.

BREAKING UP UNSERVICEABLE STORES.

CARTRIDGES FOR SMALL ARMS. 1 *Box*—1 *rectangular screen*, of brass wire, which fits in the box—1 *board*, with 4 *copper hooks*, placed across the middle of the screen—*boxes* for balls—*barrels* for powder—1 *paper press*—1 *sieve*—*stools*.

Put the bundles of cartridges on the screen, and open them there near the wire gauze; put the pieces of twine on the hooks, the papers on the board; the balls remain on the screen, and must be well washed. The serviceable papers are put under the press, the others thrown into water or burnt. The powder is dried and sifted, to separate the dust and the caked powder, which are laid by to be reworked, or to be melted for the saltpetre.

FIXED AMMUNITION FOR CANNON. 1 *Tarpaulin*—1 *box*—2 *barrels*—1 *knife*—2 *brushes*—1 *punch*—1 *hammer*—1 *scraper* (piece of sword blade)—*tow*—a *tub* half full of water, to clean the balls—*stools*.

One man holds the cartridge over the box, whilst another cuts the ligatures, takes off the strapped shot, brushes it, and stands it on the tarpaulin, on its sabot; the first man pours the good powder into a barrel, the caked powder into another, turns the bag wrong side out, and cleans it. The strapped shot are taken to the door of the laboratory, where the shot which still require cleaning are separated from their sabots and immersed in the tub of water; after standing some time they are washed and cleaned. The others remain strapped. The serviceable, reparable, and unserviceable cartridge bags are separated from each other; the last are immersed in water. The breaking up of fixed ammunition requires many precautions and should never be done in the magazine.

CANISTERS. Turn up the slit ends of the canisters, take off the covers and empty the canisters, separating the shot and bottoms.

QUILTED GRAPE. Cut the quilting, open the bag and take out the shot; then separate the bag from the stool.

PORTFIRES. Split the paper, take out the composition and pulverize it by rolling for 2 hours. It may be made to burn more or less quickly by adding mealed powder or sulphur.

Unloading Shells.

This is necessary in order to save room in the store-houses, and to prevent accidents and the deterioration of the powder. It should be performed with great care, and at a distance from the magazines.

1 Artificer—1 helper.

IMPLEMENTS. 1 *Fuze extractor*—a coil of rope, or a block, to place the shell on—1 *shell plug screw*—1 *brace*, with bits of the size of the bore of the fuzes—1 *copper chisel*—1 *wooden drift*—1 *mallet*—1 *copper hook*, and rags, to get out the powder and clean the interior of the shell—1 *knife*—a *tub* and a *basket* for the powder and fuzes—a *tarpaulin*—a *bucket of water*.

For large shells, in addition to the above: a pair of *shell hooks* and a *hand-spike*—2 *trestles* and a *frame*, to rest the shells on after extracting the fuze, for the purpose of emptying the shells over the tub.

Cut off the cap of the fuze; draw the fuze, and as soon as it is loose, hold the shell over the tub and empty it.

If the fuze breaks, or is bruised so that the extractor cannot hold it, pour water into the cup, and with the brace and bit bore out about 0.25 in. of composition; pour in more water and proceed in the same manner until the composition is removed to the depth of 3 inches; then screw in the plug-screw to the depth of 2.5 in., and bring the extractor to bear on the head of it, after wrapping it with sheet lead or putting wooden wedges around it. Disengage the plug-screw by splitting the fuze. If the plug-screw cannot be used, drive the fuze in with the wooden drift; or, if this cannot be done, bore out all the composition and wet the powder in the shell, by pouring water through the fuze; then drive in the fuze, and split it with the chisel, to get out the pieces.

If the fuze extractor is too large, or if it takes hold of the plug-screw too low down, raise it with an iron ring resting on the shell.

CHAPTER TENTH.

PACKING AMMUNITION CHESTS—LOADING ARTILLERY CARRIAGES.

CAISSON AND LIMBER.

CONTENTS OF AMMUNITION CHESTS.	GUNS.		HOWITZERS.	
	12	6	24	12
Strapped shot fixed	24	35	-	-
Canisters fixed	4	10	-	-
Strapped shells (howitzer)	-	-	12	16
Strapped spherical case shot	4	5	8	16
Canisters with sabots	-	-	3	4
Cartridges, { Large charge	2	2	2	2
	4	5	23	36
Fuzes	8	10	40	64
Portfires	6	10	5	7
Tubes	50	70	40	60
Slow match	6	6	6	6
Quick match	2	2	4	8
Bursting { for spherical case shot	4	5	8	16
	-	-	12	16
Number of rounds in each chest	32	50	23	36
do. do. in each caisson	96	150	69	108
Weight of ammunition in each chest	504	400	420	363
Weight of chest packed	632	528	563	500

An ammunition chest will hold a box of 1500 flints, with 6,500 rounds of musket ball cartridges, or 8,460 rounds of musket cartridges without the flint box. Weight of the chest packed with flint box, 660 lbs. Weight of the chest packed without the flint box, 766 lbs.

Arrangement and Manner of Packing Ammunition Chests, (Plate 14.)

The principal divisions of the chest are distinguished as the *right half* and the *left half*, to a person facing the front of the chest. The smaller divisions

in each half, perpendicular to the sides, are numbered from the principal partition each way; those parallel to the sides are distinguished as *front*, *middle*, and *rear* divisions.

Ammunition Chest for 12 pounder Gun.

FIXTURES, (poplar or white pine.) 6 *Partitions*, 3 in each half, perpendicular to the sides—24 *strips*—144 *nails*—2 *bolsters* for spherical case shot.

LOAD. *Right half*: 1st division; 4 spherical case shot with the sabots uppermost, 4 charges for ditto—2d division; 4 canisters fixed—3d and 4th divisions; 4 round shot fixed, in each.

Left half: 4 round shot fixed in each division.

The spare cartridges, the bursters, the portfires (tied up in bundles of two,) the tubes (in bundles of 10,) the match, &c., are distributed on top of the fixed ammunition.

TO PACK THE CHEST. Put a bed of tow about $\frac{1}{4}$ in. thick in the bottom of each division; place the rounds of ammunition at equal distances apart, the straps towards the angles of the divisions; pack the intervals with tow, ramming it hard about the ball, more lightly around the cartridge bags, to within half an inch of the top of the partitions. Fill the upper part of the chest with tow, in which the small stores are packed.

Ammunition Chest for 6 pounder Gun.

FIXTURES. 8 *Partitions*, 4 in each half, perpendicular to the sides—32 *strips*—128 *nails*—2 *bolsters*, for spherical case shot—1 *false cover*, in each half, with cleats to receive the pressure of the top of the chest.

LOAD. *Right half*: 1st division; 5 spherical case shot, 5 charges for ditto—2d and 3d divisions, 5 canisters fixed, in each—4th and 5th divisions, 5 round shot fixed, in each.

Left half: 5 round shot fixed, in each division.

The spare cartridges and other articles disposed of as in the 12 pdr. chest; and the load packed in the same manner, with a covering of tow.

Ammunition Chest for 24 pounder Howitzer.

FIXTURES. 4 *Large partitions*, 2 in each half, parallel to the sides—8 *linings*, 2 in the front and rear divisions of each half, perpendicular to the sides—7 *small fixed partitions*, 2 in the front division of each half, 2 in the left rear division, and 1 in the right middle division, 5.7 in. from the principal partition—20 *bolsters*, 2 in each of the small divisions, except the rear divisions of the right half

—7 *small moveable partitions*, sliding over the fixed partitions, in the same grooves, (except those in the rear division of the right half,) and having 13 *bolsters* attached to them, even with their lower edges—36 *strips*—284 *nails*—24 *screws*.

LOAD. *Right half*; rear division; 3 canisters, 4 charges lying on top of the canisters, perpendicular to the sides of the chest—middle division; in the left part, 2 spherical case shot; in the right, 9 charges, lying 3 deep, perpendicular to the sides—front division; 6 spherical case shot.

Left half: front and rear divisions, 6 shells each—middle division, 12 charges, placed as in the right half.

TO PACK THE CHEST. Take out the moveable partitions; put a bed of tow in the bottom of each division, arranging it so that there may be room for the fuze or plug; place the lower tier of shells and the canisters, with the sabots up; pack them tight with tow, to within 1 in. of the top of the sabots; replace the moveable partitions, put in the upper tier of shells, and pack them in the same manner; place the cartridges as before indicated, packed carefully in tow; the portfires, tubes, &c., as in the other chests.

Ammunition Chest for 12 pounder Howitzer.

FIXTURES. 6 *Large fixed partitions*, 3 in each half, perpendicular to the sides—6 *small fixed partitions*, 3 in each half, one being in the centre of the first division, and the other 2 in the 2nd division—8 *bolsters*, in the 3d and 4th divisions of each half, running the whole width of the chest—2 *moveable partitions* over the extreme right and left fixed partitions, with bolsters attached at their lower edges—48 *strips*—226 *nails*—16 *screws*.

LOAD. *Right half*: 1st division; rear part, 2 canisters with the sabots up, 2 charges laid on top of the canisters, one perpendicular and the other parallel to the sides of the chest; front part, 6 charges, 2 on end one over the other, 4 laid on their sides over each other—2nd division; 12 charges, 4 in each part lying down over each other—3d and 4th divisions; 16 spherical case shot, 8 in each, in 2 tiers.

Left half: 1st division; front part, 2 canisters and 2 charges; rear part, 6 charges—2nd division, 12 charges—3d and 4th divisions, 16 shells.

Portfires, tubes, &c., as before.

The chest is loaded in a similar manner to that of the 24 pdr. howitzer.

Unpacking Ammunition Chests.

Take out the tow with the tow hook from about the outside round of ammunition in a division, turning the point of the hook towards the partition in order to avoid tearing the bag; if necessary, catch the hook under the edge of the sabot to disengage the charge; the other rounds are easily removed by hand. Empty one division at a time. If it is necessary for the carriage to move with a division of the box partly emptied, pack the vacant space tight with tow.

Seize the shells and canisters by their handles.

Take out the shells of the upper tiers first, and when the carriage moves, replace the moveable partitions.

TRAVELLING FORGE.

Two forges accompanying a battery in the field; one for repairs, the other for shoeing.

*Forge for Repairs of Carriages.***Body of the Forge.**

1 Anvil and block, on the fire place.

1 Vice, on the stock.

350 Lbs. coals, in the coal chest.

Limber Box.

Against the back of the box there is a till 9 in. wide and 5.25 in. deep, with 2 partitions at 10.75 in. from the ends.

CONTENTS AND MANNER OF PACKING.

100 Lbs. square iron	-	-	-	On the bottom, against the back of the box.
50 Lbs. flat do.	-	-	-	Do. in the middle.
50 Lbs. $\frac{3}{4}$ in. round do.	-	-	-	Do. against the front.
5 Lbs. cast steel	-	-	-	} On the flat iron.
8 Lbs. English blister steel	-	-	-	
4 Nuts, No. 2	-	-	-	
6 Nuts, No. 3	-	-	-	} On the flat iron, towards the left end of the box.
10 Nuts, No. 4	-	-	-	
15 Nuts, No. 5	-	-	-	
2 Lbs. nails, No. 2	-	-	-	} On the flat iron, in the middle of the box.
20 Tire bolts, nuts and washers	-	-	-	
1 Lb. rivets for ammunition boxes	-	-	-	
20 Washers for bolt heads	-	-	-	} On the flat iron, right end of the box.
5 Keys, for ammunition boxes	-	-	-	
1 Pole prop socket and ring	-	-	-	
8 Linch washers for axletree	-	-	-	} On the square iron, back part of the box.
4 Shoulder washers	-	-	-	
4 Nave bands, developed	-	-	-	
12 Linch pins	-	-	-	On the round iron, front do. do.
2 Feet of cap-square chain	-	-	-	On the blister steel.
1 Pintle hook	-	-	-	On the nuts, left end of the box.
1 Cap square	-	-	-	On the nails and nuts, against the left end.
				On the tire bolts, do. do

CONTENTS AND MANNER OF PACKING—Continued.

1 Heading tool for limber bolts	-	-	-	On the square iron, against the back and left end of the box.
1 Double do. for No. 2 and 3 nails	-	-	-	
1 Do do. for tire bolts and rivets	-	-	-	
2 Tire punches	-	-	-	
1 Round punch	-	-	-	In the middle of the box, on the nails and bolts.
1 Square do.	-	-	-	
1 Square hand punch	-	-	-	
1 Round do.	-	-	-	
1 Prick punch	-	-	-	On the washers, right end of the box.
1 Key do.	-	-	-	
1 Set hammer, flat	-	-	-	On the bolts, in the middle of the box.
1 Do. half round	-	-	-	
1 Do. pointed	-	-	-	
1 Hand hammer	-	-	-	
1 Riveting do.	-	-	-	On the linch pins and round iron, right end of the box.
1 Nailing do.	-	-	-	
1 Sledge do.	-	-	-	
3 Chisels for hot iron	-	-	-	1 half round ; 2 straight edge.
1 Cold chisel	-	-	-	With the set hammers.
1 Hand do.	-	-	-	On the round iron, front of the box.
3 Smith's tongs	-	-	-	On the tongs.
2 Tire bands	-	-	-	On the hammers.
1 Nail claw	-	-	-	On the washers, against the back.
1 Tire circle	-	-	-	
1 Rack wrench	-	-	-	Under the till.
1 Shovel	-	-	-	
1 Poker	-	-	-	
1 Split broom	-	-	-	
1 Tap wrench, with 4 holes	-	-	-	
1 Gross 1 in. wood screws, No. 14	-	-	-	
1 Small hand vice	-	-	-	
1 Bevel vice	-	-	-	
1 Screw driver	-	-	-	
6 Taps, (1 in. $\frac{3}{4}$, $\frac{5}{8}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$)	-	-	-	In the left hand division of the till.
6 Plug taps do.	-	-	-	
1 Gimlet, 0.2 in. diameter	-	-	-	
3 Small punches	-	-	-	
1 Pair spring compasses	-	-	-	
1 Tracing point	-	-	-	
2 Augers, (1 in. and $\frac{3}{4}$)	-	-	-	
12 Files assorted, with handles	-	-	-	In the middle till.
1 Iron wire gauge	-	-	-	
1 Framing chisel	-	-	-	
1 Hardie	-	-	-	
6 Pair of dies	-	-	-	In the right hand till.
1 Scribing awl	-	-	-	
1 Pair callipers	-	-	-	
1 Quart can of oil	-	-	-	
1 Die stock	-	-	-	In the till, the handles resting on the partitions.
1 Screw plate	-	-	-	Fastened to the inside of the front of the box.
1 Felling axe	-	-	-	
1 Iron square	-	-	-	Fastened to the inside of the lid.
1 Bevel do.	-	-	-	
1 Trying do.	-	-	-	
1 Hand axe	-	-	-	
1 Buttress	-	-	-	
1 Shoeing hammer	-	-	-	
1 Do. pincers	-	-	-	
1 Do. fore punch	-	-	-	
2 Do. rasps	-	-	-	In a shoeing box, placed between the till and the front of the box.
1 Pritchell	-	-	-	
1 Toe knife	-	-	-	
1 Clenching iron	-	-	-	
1 Fuller	-	-	-	

WEIGHT of box loaded, 570 lbs.

Shoeing Forge.

Body.

As in the forge for repairs.

Limber Box.

The till is 6 in. deep, 7.25 in. wide, and has 1 partition in the centre.

CONTENTS AND MANNER OF LOADING.

100 Lbs. square iron	-	-	-	} As in the forge for repairs.
50 " flat do.	-	-	-	
50 " 3/8 round do.	-	-	-	
5 " cast steel	-	-	-	
8 " English blister steel	-	-	-	} On the square iron.
1 Shovel	-	-	-	
1 Poker	-	-	-	
1 Split broom	-	-	-	
1 Hand hammer	-	-	-	} On the flat iron.
1 Riveting do.	-	-	-	
1 Nailing do.	-	-	-	
1 Sledge do.	-	-	-	
3 Chisels for hot iron, (1 half round, 2 straight edge)	-	-	-	} On the round iron.
2 Hand cold chisels	-	-	-	
3 Smith's tongs	-	-	-	
1 Hardie	-	-	-	
12 Files assorted, with handles	-	-	-	} In the right hand till.
1 Quart can of oil	-	-	-	
300 Lbs. horse shoes	-	-	-	} In boxes, on the iron, &c.
50 " horse nails	-	-	-	
1 Buttress	-	-	-	} As in the forge for repairs.
1 Shoeing hammer	-	-	-	
1 Do. pincers	-	-	-	
1 Do. fore punch	-	-	-	
2 Do. rasps	-	-	-	
1 Pritchel	-	-	-	
1 Toe knife	-	-	-	
1 Clenching iron	-	-	-	
1 Fuller	-	-	-	

WEIGHT of box loaded, 750 lbs.

BATTERY WAGON.

There are two battery wagons to each field battery : one for carriage makers' and armorers' tools, spare parts of carriages and stores ; the other for harness makers' tools, spare harness, &c.

Contents of Wagon for Stores.

Limber Box.

1 Set of carriage makers' tools. Weight 200 lbs.—See next page.

Wagon Body.

4 Portfire stocks	2 Pounds quick-match
4 Linstocks	50 Pounds grease
3 Rammers and sponges	5 Pounds wax candles
8 Rammer and sponge heads	6 Reaping hooks
3 Priming wires	6 Scythes and snaths
3 Gunners' gimlets	6 Scythe stones
3 Pairs pincers	24 Fellies
6 Cannon spikes	40 Spokes
1 Fuze auger	2 Splinter bars
1 Gunner's callipers	2 Caisson stocks, not ironed
1 Dredging box	1 Gun carriage stock, ironed
1 Copper hammer	2 Elevating screws
2 Shell hooks	3 Pole yokes
2 Shoe knives	20 Pounds 4d to 10d nails
2 Pair scissors	2 Claw hammers
1 Fuze saw	3 Felling axes
2 Wooden bowls	3 Pick axes
3 Dark lanterns	3 Bill hooks
4 Common tin do.	6 Spades
1 Set of powder measures, 2 lbs., 1 lb., $\frac{1}{2}$ lb., $\frac{1}{4}$ lb.	1 Spare set shoeing tools
2 Copper funnels	28 Tire bolts, nuts and washers
1 Tarpaulin, (5 ft. square)	4 Gallons linseed oil
1 Copper scale and beam	25 Pounds white lead in oil
1 Pile of brass weights, 4 lbs., 2 lbs., 1 lb., 8 oz., 4 oz., 2 oz., 1 oz., $\frac{1}{2}$ oz.	10 Pounds black paint
1 Prolonge	1 Gallon spirits turpentine
100 Yards slow match	12 Paint brushes
	3 Jack screws
	1 Set armorers' tools

WEIGHT of stores, 1044 lbs.

Forage Rack.

250 Pounds forage.

Arrangement and Manner of Loading.

Limber Box.

Divided into 2 equal parts by a principal partition parallel to the sides, supported by slides of sheet iron at the ends.

The *bench planes assorted, wooden clamps, oil stone, handles for axes, adze, and hatchet*, are packed with tow in the bottom of the rear division.

The *broad axe, hand axe, and felling axe*, secured by a strip of oak extending the whole length of the box, and fastened to the back of the rear division with 5 wood screws.

The *carpenter's adze*, secured by a notch in a strip of oak which is fastened to the right end of the rear division with 3 wood screws.

A *box*, 24.5 in. long, 7 in. wide, and 3.75 in. deep, containing 1 *brace*—12 *bits assorted*—1 *pair pincers*—1 *pair callipers*—2 *spoke shaves*—2 *gauges*—6 *plane irons*—1 *saw set*—1 *bevel*—1 *rule*—6 *gimlets*—1 *pair compasses*—1 *chalk line*—2 *brad awls*—and 1 *scribe*—rests on 2 small bars of oak placed across the rear division, one end on the axe cleat, the other on brackets fixed to the partition.

6 *reamers*, on the bottom of the front division, held down by cleats with notches to pass over the shanks of the reamers.

1 *iron vice*, rests in notches on the upper side of the cleats which hold the reamers.

1 *holdfast* and 1 *lock chain hammer*, on a cleat of oak fastened by 3 screws to the left end of the front division; the handles of the hammer and vice and the grip end of the holdfast pass through the cleat; the body of the holdfast is secured to the front of the principal partition by a leather strap.

The *chisels* and some of the *gouges*, in a rack fastened to the principal partition by 3 rivets; the three *largest gouges*, in a rack on the left of the preceding, fastened by two rivets.

The *frame saw* and the *iron square*, fastened against the front side of the box by a small iron hook.

The *trying square*, *compass saw*, and *rack wrench*, secured to the front of the box by leather loops—1 box 23.75 in. long, 5.25 in. wide, and 4.25 in. deep, containing the *augers* and the *auger and reamer handles*, is packed in tow on tools in the front division.

The *saws* are kept fast by 5 cleats fastened each by 2 screws to the cover lining of the box.

Wagon body.

A *till*, the whole length of the body, 9.5 in. deep, and 9 in. wide, is placed at the top of the right side, resting on 2 cleats of oak which are fastened to the ends of the wagon, each by 3 screws.

The *gun carriage stock*, on the bottom of the wagon, against the left side, the lunette towards the back of the wagon. It rests on two blocks, of sufficient height to clear the sponge rest.

The *caisson stocks*, on the bottom against the front and right side of the wagon.

The *splinter bars*, on the bottom against the caisson stocks and the front of the wagon, lying on each other.

The *spokes*, on the bottom and against the front of the wagon, between the gun carriage and caisson stocks, piled 4 high.

The *fellies*, on the bottom between the stocks, occupying the whole space between the spokes and the back of the wagon; the fellies are piled two deep with the concavity upwards, the convex part resting on the bottom and on two spokes laid crosswise in the bottom of the wagon.

The *white lead*, in a keg 7.5 in. diameter and 10 in. high, on the bottom against the rear and right side of the wagon.

The *black paint*, in a keg 8.5 in. diameter, 10 in. high, on the bottom against the white lead and the right side of the wagon.

The *rammers* and *sponges* with staves, on the caisson stocks, against the right side and the front of the wagon.

The *sponge* and *rammer heads*, packed in tow, on the bottom against the right side and between the ends of the caisson stocks and the keg of black paint.

The *slow match*, on the rammers and sponges, against the front and right side of the wagon.

The *felling axes* and the *bill hooks*, in a rack against the left side of the wagon, above the gun carriage stock.

The *elevating screws*, packed in tow on the spokes, against the gun carriage stock and the front of the wagon.

The *spades*, on the till, on top of each other, with the bit of each spade in a rack against the back of the wagon.

The *reaping hooks*, on the till, against the right side of the wagon, secured to the side by a small wooden bar of the length of a spade handle.

The *scythes* and *sandstones*, laid down on the till against the front of the wagon, packed in tow and covered with a false cover.

The *pick axes*: the helms are taken out and packed with the pick axes in tow in the interstices of the spade handles.

The *quick match*, in a box, 14.5 in long, 6 in. wide, and 5.5 in. deep, on the false cover, over the scythes and resting against a partition which prevents spades from sliding on the shelf.

The *candles*, in a box 11 in. long, 6 in. wide, and 5.5 in. deep, on the false cover, joining the box of quick match, with a slight partition between them; the candle box towards the front of the wagon.

The *linstocks*, on the false cover, the spike ends entering slightly into the partition at the end of the spade handles, and secured in their places by the partition between the candle and quick match boxes.

The *tire bolts, nuts and washers*, laid loose on the false cover, against the front of the wagon.

The *claw hammers*, on the tire bolts.

The *cross cut saw* and the *pit saw*, on the till against the front board, their ends against the front of the wagon, secured by the parting partitions of the false cover.

The *keg of grease*, 15 in. diameter and 18 in. high, on the spokes, against the side and the front of the wagon, secured by a leather strap to the front end board.

The *linseed oil*, in a tin can 9.5 in. diameter, 14 in. high, on the spokes, against the keg of grease, and secured to the front of the till by a leather strap.

The *spirits turpentine*, in a tin can 5 in. diameter and 11.5 in. high, on the spokes, between the oil can and the gun carriage stock.

The *nails*, in a box 13 in. long, 13 in. wide, and 5 in. deep, on the gun carriage stock, against the front and the right side of the wagon.

The *tin lanterns*, packed in tow, on the spokes, between the till and the gun carriage stock.

The *pole yokes*, in the hollow of the fellies.

The *armorers' tools* in a box 19.5 in. long, 19.5 in. wide, and 10.5 in. deep, on the fellies, against the back of the wagon and the till.

The *tarpaulin*, on the gun carriage stock, between the left side of the wagon and the box of armorers' tools, against the rear end board.

The *laboratory tools and stores*, in a box 28.5 in. long, 16.5 in. wide, and 10.5 in. deep, on the fellies, against the till and the armorers' tool box.

The *spare set of shoeing tools*, on the spokes against the gun carriage stock.

The *jacks*, on the gun carriage stock, between the left side of the wagon and the laboratory tool box.

The *prolonge*, on the gun carriage stock, against the left side of the wagon.

The *scythe sneaths*, secured to the inner side of the cover by leather straps.

Contents of Wagon for Harness.

Harness for 16 horses	1 Pair pliers
60 Yards trace rope	1 Claw tool
2 Sides harness leather	1 Creaser
2 Sides bridle do.	1 Tarpaulin (5 feet square)
12 Spare nose bags	3 Lbs. bees-wax
6 Sets forage cord	5 Lbs. black wax
24 Spare corn sacks	8 Oz. bristles
3 Pole yokes	5 Lbs. shoe thread
1000 Tacks assorted	2 Lbs. patent do.
1 Saddler's hammer	1 Quart sweet oil
1 Shoe knife	4 Gallons neat's foot do.
1 Half moon knife	2 Dozen harness buckles, assorted
1 Mallet	14 Havresacks
1 Pair shears	8 Tube pouches
1 Clam	8 Portfire cases
1 Sandstone	8 Thumbstalls
1 2-foot rule	200 Lbs. bar iron, assorted
25 Needles	50 Lbs. bar steel do.
5 Collar needles	2 Axle trees
12 Awls assorted	4 Half tires
1 Punch	250 Lbs. forage (in the forage rack)
1 Pair pincers	

The havresacks, tube pouches, portfire cases, thumbstalls, and the greater part of the tools and small stores, in the limber box which is furnished with racks to receive them. The articles of iron and steel in the bottom of the wagon body; the harness and the rest of the stores piled on them.

CHAPTER ELEVENTH.

TRAINS OF ARTILLERY—ARMAMENT OF FORTIFICATIONS.

FIELD TRAIN.

Ordnance.

The proportion of artillery to other troops varies generally between the limits of 1 and 3 pieces to 1,000 men, according to the force of the army, the character of the troops of which it is composed, the force and character of the enemy, the nature of the country which is to be the theatre of war, and the character and objects of the war.

Similar considerations must regulate the selection of the kinds of ordnance and the proportions of the different kinds in the train.

The following principles may be observed in ordinary cases :

2 pieces to 1,000 men	{	$\frac{2}{3}$ guns, of which	{	$\frac{1}{4}$ are 12 pdrs.	
				$\frac{3}{4}$ " 6 pdrs.	
				$\frac{1}{3}$ howitzers, of which	$\frac{1}{4}$ " 24 pdrs.
				$\frac{2}{3}$ " 12 pdrs.	

Distributed as follows :

For the infantry : 1 piece to 1,000 men—6 pdr. guns and 12 pdr. howitzers, in batteries of foot artillery.

For the cavalry : 2 pieces to 1,000 men—6 pdr. guns and 12 pdr. howitzers, in batteries of horse artillery.

For the special and general parks of reserve :

1 piece to 1,000 men	{	$\frac{1}{2}$ in 12 pdr. batteries	} of foot artillery.
		$\frac{1}{3}$ " 6 pdr. do.	
		$\frac{1}{6}$ " 6 pdr. batteries of horse artillery.	

Ammunition for Cannon.

200 Rounds to each piece, both of the reserves and of the active batteries.

The ammunition which cannot be carried in the caissons attached to the pieces will be kept in boxes with the reserves.

Proportion of the different kinds of ammunition and other supplies:

KIND.	For Guns.		For Howitzers.		
	12	6	24	12	
Strapped shot fixed, - -	76	70	-	-	} For 100 rounds.
Canisters fixed, - -	12	20	-	-	
Strapped shells, - -	-	-	52	48	
Spherical case shot, strapped -	12	10	35	40	
Canisters with sabots - -	-	-	13	12	
Cartridges, { Large charge, (spare,) -	6	4	8	6	
{ Small charge -	12	10	100	100	
Fuzes - - - -	twice the number of shells and spherical case shot.				
Portfires - - - -	1 to 5 rounds.				
Tubes - - - -	$\frac{1}{2}$ more than the number of rounds.				
Slow match - - - -	1 yard to 5 rounds.				
Quick match - - - -	$\frac{1}{4}$ yard to each spherical case shot.				
Bursters - - - -	1 to each shell and spherical case shot.				

Additional supplies of ordnance and ordnance stores are placed in convenient depôts, according to circumstances.

Ammunition for Small Arms.

100 Rounds to each man; of which, for the musket, 40 rounds are in the cartridge box, 60 in the parks of reserve. In the same proportion for other small arms.

5 Flints to 100 rounds.

Percussion caps for carbines, $\frac{1}{2}$ more than the number of cartridges.

Composition of a Battery on the War Establishment.

KIND OF BATTERY,				12 Pdr.	6 Pdr.
Guns,	{	12 pounders, mounted	- - -	4	-
	{	6 pounders do.	- - -	-	4
Howitzers,	{	24 pounders do.	- - -	2	-
	{	12 pounders do.	- - -	-	2
Total number of pieces mounted			- - -	6	6
Carriages,	{	Gun carriages, (spare)	- - -	1	1
		Caissons	- - -	12	6
		Forges, (1 for repairs and 1 for shoeing)	- - -	2	2
		Battery wagons, (1 for repairs, 1 for harness)	- - -	2	2
Total number of carriages			- - -	17	11

Implements and Equipments.

FOR EACH GUN CARRIAGE.

2 Gunner's haversacks.
1 Tube pouch
1 Portfire case.
2 Thumbstalls.
1 Priming horn.
1 Prolonge.
1 Vent cover and strap.
1 Linstock.
1 Portfire stock.
1 Priming wire.
1 Fuze auger.
1 Fuze saw.
1 Fuze sett.

1 Vent punch.
1 Gunner's gimlet.
1 Tangent scale.
1 Pair portfire cutters.
2 Sponges and rammers.
2 Sponge covers.
 $\frac{1}{2}$ Worm and staff.
2 Handspikes.
1 Sponge bucket.
1 Tow hook.
1 Fuze rasp.
1 Fuze mallet.
1 Shell plug screw.

FOR EACH HOWITZER CARRIAGE, (Additional.)

1 Fuze extractor.
1 Copper funnel.

1 Gunner's quadrant.
1 8-ounce powder measure.

FOR EACH CAISSON.

1 Felling axe.
1 Shovel.
1 Pick.
1 Spare pole, (one-half of them ironed.)
1 Spare wheel, to each caisson of the reserves.

1 Spare handspike.
1 Tar bucket.
3 Tow hooks.

FOR EACH FORGE.

1 Water bucket.

| 1 Shovel.

DRAUGHT HORSES.—6 to a battery wagon and 12 pdr. gun carriage—4 to other carriages—1-12th spare.

HARNESS, corresponding with the number of horses to the carriages.

The equipments required for the immediate service of a piece are carried, on the march, in the ammunition chest of the limber.

SIEGE TRAIN.

The number and kind of cannon for a siege train must be determined by the circumstances of each case, but the following general principles may be observed in assigning the proportion of different kinds and calibres, and the relative quantity of other supplies, for a train of 100 pieces of ordnance.

Cannon.

GUNS,	{	24-pdr.,	about one-third of the whole number	32
		18-pdr.,	" one-tenth "	10
		12-pdr.,	" one-tenth "	10
HOWITZERS,		8-in. siege,	" one eighth "	13
MORTARS,	{	10-in. siege,	" one-seventh "	14
		8-in. siege,	" one-fourteenth "	7
STONE MORTARS,			" one-seventh "	14
COEHORN MORTARS, (in addition to the 100 pieces,)				6
WALL PIECES, for the attack of one front				40

Gun Carriages.

For 24-pdr. guns and 8-in. howitzers, one-third spare	-	60
For 18-pdr. and 12-pdr. guns, one-fourth spare	-	25
For 10-in. mortars and stone mortars, one-third spare	-	38
For 8-in. mortars and stone mortars, one-fourth spare	-	9

Other Carriages.

Transporting carriages for mortars.	1 for each 10-in. mortar and bed,	
	for each stone mortar and bed, and for three 8-in. mortars and beds	38
Wagons, for transporting implements, &c., intrenching and miner's tools, laboratory tools and utensils, and other stores—each loaded with about 2,700 lbs., say		140

<i>Trench carts</i> , (carrying balls, &c., on the march,) - - - - -	50
<i>Battery wagons</i> , 1 to 100 horses - - - - -	28
<i>Forges</i> , fully equipped - - - - -	8
<i>Sling carts</i> - - - - -	5

Draught Horses.

For each 24-pdr. and 18-pdr. gun, and 8-in. howitzer with its carriage	8
“ 12-pdr. gun do.	6
“ Spare gun carriage and forge - - - - -	4
“ Transporting carriage for mortars - - - - -	8
“ Park and battery wagon - - - - -	6
“ Trench cart - - - - -	2
“ Sling cart - - - - -	2
Spare horses - - - - -	1-10th
Total, say - - - - -	1,800

Projectiles and Ammunition.

FOR GUNS.	{	Round	1000 to each 24-pdr.	-	-	-	32,000
		shot.	1000 to each 18 "	-	-	-	10,000
			1200 to each 12 "	-	-	-	12,000
	Grape and canister,	50 rounds to each piece	-	-	-	2,600	
	Spherical case,	100 rounds to each piece	-	-	-	5,200	
FOR HOWITZERS.	{	Shells,	800 to each 8-inch	-	-	-	10,400
		Canisters	50 do.	-	-	-	650
		Spherical case,	100 do.	-	-	-	1,300
FOR MORTARS.	{	600 Shells to each	10-inch	-	-	-	8,400
		800 " "	8-inch	-	-	-	5,600
		600 " "	Coehorn	-	-	-	3,600
Gunpowder, in barrels				-	-	-	lbs. 500,000
Computing for each round shot,				-	-	$\frac{1}{4}$ the weight of shot.	
"	"	grape, canister, and spherical case,				1-6 do.	
"	"	round of howitzer ammunition,				5 lbs.	} including charge of shell.
"	"	"	10-inch mortar,	7 "			
"	"	"	8-inch do.,	3			
"	"	"	Coehorn,	$\frac{1}{2}$ "			
"	"	"	Stone mortar,	1 "			
Paper cartridge bags, 400 to each piece				-	-	-	40,000
Cartridge paper, bundles				-	-	-	200

<i>Sabots</i> , 200 to each gun and howitzer	-	-	-	-	-	13,000
<i>Slow match</i>	-	-	-	-	-	lbs. 4,500
<i>Portfires</i>	-	-	-	-	-	8,000
<i>Priming tubes</i>	-	-	-	-	-	80,000
<i>Fuzes</i> , $\frac{1}{4}$ more than the number of shells	-	-	-	-	-	40,000
<i>Wooden bottoms and baskets</i> for stone mortars, 800 to each	-	-	-	-	-	11,200
<i>Percussion primers</i> , for pieces furnished with locks, $\frac{1}{4}$ to spare.						
<i>Cartridges for wall pieces</i> , 500 rounds to each.						
<i>Cartridges, powder, flints and lead</i> for small arms, according to the force of the army.						

Most of the ammunition is transported by hired wagons.

Implements and Equipments.

FOR EACH GUN.

3 Sponges—2 spare	2 Thumbstalls
2 Rammers—1 do.	2 Priming wires—1 spare
$\frac{1}{3}$ Worms	1 Gunner's gimlet
$\frac{1}{3}$ Ladles	1 Tangent scale
8 Handspikes—2 spare	2 Mauls
2 Linstocks—1 spare	1 Vent cover
1 Portfire stock	1 Sponge bucket
1 Pass box	1 Broom
1 Tube pouch	1 Percussion lock
1 Priming horn	

FOR EACH HOWITZER AND MORTAR.

IMPLEMENTS.	HOWITZER.	MORTAR.
Sponges and rammers	3—2 spare	2—1 spare
Ladles	$\frac{1}{3}$	—
Handspikes, (2 shod, for mortar)	6—2 spare	6—2 spare
Linstocks	2—1 spare	2—1 spare
Portfire stocks	1	1
Havresacks	1	1
Priming wires	2—1 spare	2—1 spare
Gunner's gimlets	1	1
Quadrants	1	1
Mauls	2	2
Fuze drifts	2—1 spare	*2—1 spare
Mallets	2—1 spare	*2—1 spare
Baskets	1	1

FOR EACH HOWITZER AND MORTAR—*Continued.*

IMPLEMENTS.	HOWITZER.	MORTAR.
Tompions - - - - -	1	1
Sponge bucket - - - - -	1	1
Broom - - - - -	1	1
Percussion locks - - - - -	1	-
Plummets - - - - -	-	1
Pointing wires - - - - -	-	*2
Quoins - - - - -	-	2
Shell hooks - - - - -	-	*2—1 spare
Scrapers - - - - -	-	1
Spatulas - - - - -	-	*1
Gunner's sleeves (pair) - - - - -	-	1
Sand bags, to wipe with - - - - -	-	1

Scales and weights, funnel, set of powder measures of 3 sizes, shell plug screw and fuze extractor, to each battery magazine.

Implements marked * are not required for the stone mortar. The number of implements must be proportioned to the whole number of gun carriages, including the spare carriages.

Platforms.

For guns and howitzers, 1-10th spare	-	-	-	72
For mortars, 1-8th do.	-	-	-	40

Embrasure Shutters.

$\frac{1}{2}$ the number of guns and howitzers	-	-	-	33
--	---	---	---	----

Spare Parts of Carriages, &c. (See Armament of Fortifications.)

Spare parts of field carriages, as for field batteries. See Chapter 10.

Timber and other Materials for Repairs.

Proportion to the number of parts that enter into the construction of the carriages:

Axle bodies for siege carriages 1-50th—Breech bolsters 1-20th—Cheeks 1-30th—Fellies 1-50th—Spokes 1-30th—Fork saddles 1-30th—Poles 1-20th—Hounds 1-20th—Splinter bars 1-20th—Double trees 1-10th—Square timber of

various scantling—Plank—Wooden parts of transporting carriages; of each 1-20th.

Bar iron assorted, 80 lbs. to a piece, 8,000 lbs.—Steel, 5 lbs. to a piece, 500 lbs.—Sheet iron, 50 sheets—Iron wire, 400 lbs.—Sheet tin, 100 sheets—Nails and screws, assorted.

Machines and Ropes.

7 Gins, with tackle, complete—34 Lever Jacks—14 Jack screws—20 Wheelbarrows, 1-5th for shells—7 Handbarrows—Balances, for weighing—10 Spare gin falls—75 Double prolonges—75 Single prolonges—Drag ropes, 200—Trace ropes, 300—Men's harness, 50—Small ropes, 200 lbs.—Twine, of various sizes, 50 lbs.

Tools.

Sets of carriage makers' and blacksmiths' tools—Pioneers' tools, for the artillery alone, 40 to a piece, say 4,000; of which 1,600 spades, 270 shovels, 2,000 mattocks, 130 picks—Spare tool handles $\frac{1}{2}$.

Axes, 5 to a piece, 500—Bill hooks, 10 to a piece, 1,000—Saws, various kinds, 200—10-Foot rods, 2-foot rules, masons' levels, 100 of each—Paviours' rammers, 200—Mauls, 200—Scythes, 8—Miners' tools—Baskets.

Laboratory Tools and Materials.

2 Sets of laboratory tools; See Chapter 9.

Nitre, pulverized	-	1500 lbs.	Twine	-	50 lbs.
Sulphur, pulverized	-	100 "	Tarred rope yarn	-	200 "
Sulphur, roll	-	100 "	Copper wire	-	10 "
Pitch	-	150 "	Brass wire	-	10 "
Rosin	-	150 "	Cotton yarn	-	25 "
Beeswax	-	50 "	Glue	-	10 "
Charcoal, pulverized	-	200 "	Wrapping paper	-	10 reams.
Camphor	-	20 "	Tar	-	20 barrels
Spirits turpentine	-	10 gals.	Mealed powder	-	300 lbs.
Sperm oil	-	5 "	Quick match	-	150 "
Linseed oil	-	2 "	Torches	-	100 "
Tow—Tarred links—Fire stone, &c.					

Implements for firing hot shot.

See CHAPTER 15.

Instruments, Books, &c.

2 Theodolites, or other instruments for measuring angles—2 Levels and staves—2 Compasses—4 Surveying chains—Diagonal scales—Cases of mathematical instruments—Spy glasses.

Tables of artillery construction—Tables of firing—Logarithmic tables—Drawing paper.

Miscellaneous Supplies.

Smiths' coal, 20 tons—Grease, in barrels—Sand bags, 500 to each piece of ordnance—Chevaux de frise—Scaling ladders—Rampart grates, 50—Tarpaulins, various sizes, 100—2 Grindstones—Lanterns, 100—Sperm candles, 150 lbs.—Lamp lighter's torches—Tinder boxes, &c.—Canvass.

ARMAMENT OF FORTIFICATIONS.

The kind and number of pieces of ordnance required for the armament of each of the fortifications are prescribed by the Secretary of War, according to their character and extent.

The carriages, ammunition, implements, equipments, and other supplies, for a fort placed on the war establishment, may be proportioned to the number of pieces on the following general principles, the application of which must, however, be regulated by the importance of the position, and by the peculiar circumstances of each case.

<i>Carriages.</i>		For a front of attack.	For other land fronts and for sea coast batteries.	
GUN CARRIAGES.	Casemate -	1-6th	1-8th	} more than the number of pieces.
	Barbette -	1-3d	1-6th	
	Siege -	1-3d	1-6th	
	Field -	1-3d	-	
	Mortar beds -	1-4th	1-4th	
Trench carts, for advanced works -		1 to 20 pieces.	-	
Sling carts -		1 to 25 pieces.	1 to 25 pieces.	
Tumbrils or hand carts -		1 to 20 pieces.	1 to 20 pieces.	
Caissons -		1 to each field piece.	-	
Forges, travelling, (besides permanent forges) -		1 to 30 pieces of all kinds.	-	
<i>Ammunition.</i>				
For each gun and sea coast howitzer -		800 rounds.	250 rounds	} Grape and can.
For each carronade -		100 "	100 "	
For each siege howitzer -		600 "	200 "	
For each 10-in. mortar -		400 "	-	
For each mortar -		-	200 "	
For 8-in. stone mortar and Coehorn -		600 "	-	

100 lbs. of stone to each charge of a stone mortar.

Rampart grenades, 300 to a front of attack.

For each piece of artillery of a battery for sorties, 400 rounds.

Gunpowder. The quantity of cannon powder may be calculated on the following principles :

For each charge of a gun— $\frac{1}{4}$ of the weight of the shot.

Do.	do.	carronade or 24 pdr. howitzer,	2 lbs.	
Do.	do.	8-in. siege howitzer	-	4 "
Do.	do.	10-in. seacoast do.	-	12 "
Do.	do.	8-in. do. do.	-	8 "
Do.	do.	10-in. mortar (light)	-	7 "
Do.	do.	10-in. do. (heavy)	-	15 "
Do.	do.	8-in. do.	-	3 "
Do.	do.	13-in. do.	-	30 "
Do.	do.	Stone mortar	-	1
Do.	do.	Coehorn	-	$\frac{1}{2}$ "

} including the
charge of the
shell.

To spare ; for mining, fireworks and waste, $\frac{1}{10}$ of the whole, including a proportion of mealed powder and its components, pulverized.

Fuzes, $\frac{1}{4}$ more than the number of shells.

Tubes, $\frac{1}{2}$ more than the number of rounds.

Slow match, 40 lbs. to a piece.

Cannon cartridge paper, 1 sheet to a round.

Sabots—*Wooden bottoms* for stone mortars.

Portfires, 1 to 15 rounds.

Percussion primers, $\frac{1}{4}$ more than the number of rounds, for pieces furnished withlocks.

Small Arms.

Muskets	-	-	-	$\frac{1}{3}$	} more than the number of troops of the several kinds, supposed to be fully armed and equipped.
Musketoons	-	-	-	$\frac{1}{3}$	
Pistols	-	-	-	$\frac{1}{3}$	
Artillery and Infantry swords	-	-	-	$\frac{1}{25}$	
Cavalry sabres	-	-	-	$\frac{1}{5}$	

Wall pieces—50 to a front of attack, or a front exposed to escalade.

Ammunition : Musket cartridges, for each man - - 400

Muskatoon, pistol, and rifle cartridges - 100

Cartridges for each wall piece - - 400

Spare powder for small arms, $\frac{1}{25}$ of the whole quantity required for the cartridges—Cartridge paper in proportion.

Flints, 1 to 10 rounds—Percussion caps, $1\frac{1}{2}$ to a round, for arms with percussion locks.

Implements and Equipments.

FOR EACH GUN.	FOR EACH HOWITZER.
2 Rammers—1 spare. 2 Sponges—1 do. $\frac{1}{3}$ Worms. $\frac{1}{3}$ Ladles. 2 Linstocks—1 spare. 1 Portfire stock. 1 Pass box. 2 Budge barrels. 1 Tube pouch. 1 Priming horn. 2 Thumbstalls—1 spare. 2 Priming wires—1 do. 1 Gunners' gimlet. 1 Hausse, or tangent scale. 1 Vent cover, or lock cover. 1 Percussion lock. 1 Water bucket.	The same as for a gun, omitting <i>pass box</i> , and adding : 1 Haversack. 2 Fuze setters. 2 Fuze mallets. 1 Fuze extractor to 6 pieces. 1 Quadrant. 1 Fuze saw. 1 Fuze gimlet.

FOR EACH MORTAR :

2 Sponges and rammers.
6 Hand spikes—4 shod.
2 Linstocks.
1 Havresack.
1 Tube pouch.
2 Priming wires.
1 Gunner's gimlet.
1 Quadrant.
1 Plummet.
2 Pointing wires.
2 Quoins.
1 Tompion.

2 Shell hooks.
1 Scraper.
1 Spatula.
1 Pair gunner's sleeves.
1 Sand bag.
2 Fuze setters.
2 Mallets. } 1 spare.
2 Fuze saws.
 $\frac{1}{3}$ Fuze extractors.
1 Basket.
1 Broom.
1 Tarpaulin.

The implements for *shells* are not required for the stone mortar.

FOR EACH CASEMATE CARRIAGE : (including the spare carriages.)

2 Traversing handspikes—2 Truck handspikes—1 Quoin, or elevating machine—4 Chocks, 2 spare—1 Broom.

FOR EACH BARBETTE CARRIAGE : 4 Manœuvring handspikes, 2 spare—1 Tarpaulin or other cover—1 Platform and 2 mauls; if the platform is not permanent.

FOR EACH SIEGE CARRIAGE : 4 Handspikes, 2 spare—2 Mauls—1 Platform.

Spare Parts for Repair of Carriages.

Proportion of the number of spare parts to that of similar parts which belong to the carriages:

Forks for traversing wheels of barbette carriages	-	-	1-20th.
Pintles for siege carriage limbers	-	"	1-30th.
Pintles for casemate carriages	-	-	1-20th.
Linch pins	-	-	1-5th.
Axletrees	{	for siege carriages	1-20th.
	{	for carbette carriages	1-40th.
	{	for casemate carriages	1-40th.
Rollers for casemate carriages	-	-	1-40th
Bolster plates, for pintles not permanently fixed	-	-	1-40th
Wheels,	{	for siege carriages	1-15th
	{	for barbette upper carriages, (including rollers)	1-20th
	{	for casemate do.	1-40th
	{	for carbette chassis	1-40th
	{	for casemate chassis	1-40th
Axle washers,	{	shoulder	1-20th
	{	linch	1-10th
Poles, for siege carriage limbers, one-half ironed	-	-	1-4th
Elevating screws	-	-	1-8th
Double trees, for siege carriages, one-half ironed	-	-	1-4th
Tongues (iron) for casemate carriages	-	-	1-10th
Nuts, assorted	-	-	1-10th

Timber and other Materials for Repairs.

Cheeks, stocks, naves, spokes, fellies, for siege carriages; of each 1-20th—Cheeks of mortar beds, 1-12th. Handspikes, 4 to a piece—Tool handles, $\frac{1}{2}$ —Sets of timber for barbette carriages, 1-20th. Ditto casemate, 1-40th—Iron assorted, 50 lbs. to each piece—Nails and screws assorted, 100 to each piece—Steel, 1 lb. to each piece—Sheet iron, 6 square feet to each piece—Tin, 5 sheets to each piece—Spare parts for small arms, see *Chapter 6*.

Machines, Ropes, &c.

Gins, casemate and rampart, as may be required, according to the extent of the fort—Jack screws—Capstans—Lever jacks—Wheelbarrows, 1 to each piece—Handbarrow, for shells, 1 to each mortar—Sling handbarrow and frame handbarrow with legs, 1 to each gun and howitzer—Platform balance, or scales

and weights—Gin falls, 1-5th spare—Double prolonges, 2 to each gin—Drag ropes—Trace ropes—Small rope, 5 lbs. to a piece.

Tools.

Sets of carriage makers', smiths' and armorers' tools—Intrenching and miners' tools—Saws—Levels—Paviours' rammers—10-foot rods—2-foot rules—the number of each kind to be regulated by the particular circumstances of each case.

Tools and Materials for Fireworks, &c.—See Chapter 9.

Laboratory tools and materials, according to the extent and resources of the fort; see the proportion of those for a siege train. For each night of a siege, or for each night on which the guns will probably be served, have 6 tarred links to each piece mounted on the ramparts of a front of attack, or of a sea coast battery, and 5 fire balls for a front of attack—6 carcasses for each large mortar on a front of attack.

Signal rockets—Torches—Fire stone, &c.—according to circumstances.

Instruments, Books, Stationery, &c.

According to the character and extent of the fort—See *Siege Train*.

Miscellaneous Supplies.

Timber, plank, and boards—Wood for sabots, fascines, gabions, &c.—Pickets—Coal, 5 tons to a forge—Grease—Grindstones—Rampart grates, 2 to each piece on the ramparts—Sand bags, for the batteries of the front of attack—Lantern, 1 to each piece—Candles—Oil—Fire engine and buckets.

Field pieces, forming a part of the armament of a fortification, should be provided with their caissons, ammunition, &c., as for service in the field.

CHAPTER TWELFTH.

MATERIALS.

TIMBER.

The kinds of wood principally used in ordnance constructions are the following:

WHITE OAK, (*Quercus alba*.) The bark is white, the leaf long, narrow and deeply indented; the wood is of a straw color with a somewhat reddish tinge, tough and pliable; it is the principal timber used for ordnance purposes, being employed for all kinds of artillery carriages.

WHITE BEECH—RED BEECH, (*Fagus sylvestris*—*Fagus ferruginea*,) are the most suitable for fuzes, mallets and fuze setters; also for plane stocks and various other tools.

WHITE ASH, (*Fraxinus Americana*,) is straight grained, tough and elastic, and is therefore suitable for light carriage shafts; in artillery, it is used chiefly for sponge and rammer staves; sometimes for handspikes, and for sabots and tool handles.

ELM, (*Ulmus Americana*,) is well suited for fellies and for small naves.

HICKORY, (*Juglans tomentosa*,) is very tough and flexible; the most suitable wood for handspikes and tool handles, and for wooden axletrees.

BLACK WALNUT, (*Juglans nigra*,) is hard and fine grained; it is preferred for naves, and the plank is used for ammunition boxes; it is used exclusively for the stocks of small arms.

WHITE POPLAR, OR TULIP TREE, (*Liriodendron tulipifera*,) is a soft, light, fine grained wood, which grows to a great size; it is used for sabots, cartridge blocks, &c., and for the lining of ammunition boxes.

WHITE PINE, (*Pinus strobus*,) is used for arm chests and packing boxes generally.

CYPRESS, (*Cupressus disticha*,) is a soft, light, straight grained wood, which grows to a very large size. On account of the difficulty of procuring oak of suitable kind in the Southern States, cypress has been used for sea-coast and garrison carriages. It resists better than oak the alternate action of heat and

moisture to which sea-coast carriages are particularly exposed in casemates ; but being of inferior strength, a larger scantling of cypress than of oak is required for the same purpose, and on account of its softness it does not resist sufficiently the friction and shocks to which such carriages are liable.

BASS WOOD OR AMERICAN LIME, (*Tilia Americana*), is very light, not easily split, and is excellent for sabots, cartridge blocks, and for large fuzes.

DOG WOOD, (*Cornus florida*), is hard and fine grained, suitable for mallets, drifts, &c.

Selection of Standing Trees.

The principal circumstances which affect the quality of growing trees are *soil*, *climate*, and *aspect*.

In a moist soil, the wood is less firm and decays sooner than in a dry, sandy soil, but in the latter the timber is seldom fine ; the best is that which grows in a dark soil mixed with stones and gravel ; this remark does not apply to the poplar, willow, cypress and other light woods, which grow best in wet situations.

In the United States, the climate of the Northern and Middle States is most favorable to the growth of the timber used for ordnance purposes, except the cypress.

Trees growing in the centre of a forest or on a plain are generally straighter and more free from limbs than those growing on the edge of the forest, in open ground, or on the sides of hills, but the former are at the same time less hard. The aspect most sheltered from the prevalent winds is generally most favorable to the growth of timber. The vicinity of salt water is favorable to the strength and hardness of white oak.

The selection of timber trees should be made before the fall of the leaf. A healthy tree is indicated by the top branches being vigorous and well covered with leaves ; the bark is clear, smooth, and of a uniform color. If the top has a regular, rounded form, if the bark is dull, scabby, and covered with white and red spots, caused by running water or sap, the tree is unsound. The decay of the uppermost branches, and the separation of the bark from the wood, are infallible signs of the decline of the tree.

Felling Timber.

The most suitable season for felling timber is that in which vegetation is at rest, which is the case in midwinter and in midsummer ; recent opinions, derived from facts, incline to give preference to the latter season, say the month of July ; but the usual practice is to fell trees for timber between the first of De-

ember and the middle of March. Some experiments are in progress with a view to determine the question with regard to oak timber for ordnance purposes.

The tree should be allowed to obtain its full maturity before being felled; this period in oak timber is generally at the age of from 75 to 100 years or upwards, according to circumstances. The age of hard wood is determined by the number of rings which may be counted in a section of the tree.

The tree should be cut as near the ground as possible, the lower part being the best timber; the quality of the wood is in some degree indicated by the color, which should be nearly uniform in the heart wood, a little deeper towards the centre, and without sudden transitions.

Felled timber should be immediately stripped of its bark, and raised from the ground.

Defects of Timber Trees, (especially of Oak.)

Sap, the white wood next to the bark, which very soon rots, and should never be used, except that of hickory. There are sometimes found rings of light colored wood surrounded by good hard wood; this may be called the *second sap*; it should cause the rejection of the tree in which it occurs.

Brash wood, is a defect generally consequent on the decline of the tree from age; the pores of the wood are open, the wood is reddish colored, it breaks short, without splinters, and the chips crumble to pieces. This wood is entirely unfit for artillery carriages.

Wood which has died before being felled should in general be rejected; so should *knotty trees*, and those which are covered with tubercles or excrescences.

Twisted wood, the grain of which ascends in a spiral form, is unfit for use in large scantling, but if the defect is not very decided, the wood may be used for naves and for some light pieces.

Splits, checks and cracks, extending towards the centre, if deep and strongly marked, make the wood unfit for use, unless it is intended to be split.

Wind shakes, are cracks separating the concentric layers of wood from each other; if the shake extends through the entire circle, it is a ruinous defect.

All the abovementioned defects are to be guarded against in procuring timber for use in artillery constructions; the *centre heart* is also to be rejected in nearly all cases.

Seasoning and Preserving Timber.

As soon as practicable after the tree is felled, the sap wood should be taken off and the timber reduced, either by sawing or splitting, nearly to the dimensions required for use. Pieces of large scantling, or of peculiar form, such as those for the bodies of gun carriages and for chassis, are got out with the saw;

those of smaller dimensions, such as spokes, fellies, handspikes, &c., are split with wedges. Naves should be cut to the proper length and bored, through the axis, with a $1\frac{1}{2}$ in. auger, to facilitate their seasoning and to prevent cracking as much as possible. They should be cut from the butt of the tree.

Timber of large dimensions is improved by *immersion in water* for some weeks, according to its size, after which it is less subject to warp and crack in seasoning.

For the purpose of seasoning, timber should be piled under shelter, where it may be kept dry, but not exposed to a strong current of air; at the same time, there should be a free circulation of air about the timber, with which view slats or blocks of wood should be placed between the pieces that lie over each other, near enough together to prevent the timber from bending. In the sheds, the pieces of timber should be piled in this way, or in square piles, and classed according to age and kind. Each pile should be distinctly marked with the number and kind of pieces, and their age, or the date of receiving them. The piles should be taken down and made over again at intervals, varying with the length of time which the timber has been cut. The seasoning of timber requires from 2 to 4 years, according to its size.

Gradual drying and seasoning in this manner is considered the most favorable to the durability and strength of timber, but various methods have been proposed for hastening the process. For this purpose, *steaming or boiling* timber has been applied with success; and the result of experiments with Mr. Kyan's process of saturating timber with a solution of corrosive sublimate, have been highly satisfactory; this is said to harden and season the wood, at the same time that it secures it from the dry rot and from the attacks of worms. This process is now under trial in the Ordnance Department, and also that of Mr. Earle, which consists in saturating the wood with a solution of copperas and blue vitriol mixed together. *Kiln drying* is serviceable only for boards and pieces of small dimensions, and is apt to cause cracks and to impair the strength of wood, unless performed very slowly. *Charring or painting* is highly injurious to any but seasoned timber, as it effectually prevents the drying of the inner part of the wood, in which consequently fermentation and decay soon take place.

Oak timber loses about *one-fifth of its weight* in seasoning, and about *one-third of its weight* in becoming perfectly dry.

Measuring Timber.

Sawed or hewn timber is measured by the cubic foot, or more commonly by *board measure*, the unit of which is a superficial foot of a board 1 in. thick. Small pieces, especially those which are got out by splitting, (such as hand-

spikes, spokes, &c.) and *shapes*, or pieces roughed out to a particular pattern, (such as stocks for small arms, fellies, &c.) are purchased by the piece.

Usual rule for measuring round timber :

Multiply the length by the square of $\frac{1}{4}$ the mean girth, for the solid contents ; or, $\frac{L C^2}{16}$; L being the length of the log, and C half the sum of the circumferences of the two ends. But when round timber is procured for use in the Ordnance Department, it should be measured according to the square of good timber which can be obtained from the log.

IRON.

Iron is obtained from ores in which it generally exists in the state of an oxide, combined with earthy or stony matters, and sometimes with *sulphur*, *arsenic*, *magnesia*, *manganese*, &c. Iron ores are classed and named according to their different combinations, as *magnetic*, *specular*, *micaceous*, *red hematite*, *brown hematite* ; the last named is the ore from which the Salisbury and the Juniata irons are extracted.

Making Pig Iron.

Roasting. To obtain pig iron, the ore is first roasted, to separate such of the foreign substances as can be consumed or volatilized by a moderate heat ; for this purpose the ore is distributed in layers alternately with refuse coal or charcoal, and burnt in the open air, or in a kiln similar to that used for burning lime ; when sufficiently calcined, the ore is easily broken into pieces of the proper size for smelting.

Smelting, separates the iron from the refractory substances with which it is combined in the ore ; it is effected in the blast furnace, by exposing the ore to a great heat, in conjunction with a suitable flux of limestone or clay, which combining with the earthy matter runs off over the dam, in a cinder, leaving the iron to settle at the bottom of the furnace, where it is protected from the blast by the cinder, and kept hot and fluid, until it is drawn off into open channels or moulds, in the form of *pigs*, which is usually done every twelve hours.

The kinds of fuel used for smelting are charcoal, bituminous coal, coke, and very recently, anthracite coal. For many purposes, such as sheets for tinning, bars for converting into steel, *charcoal iron* is exclusively used, and for bar iron, it is superior to that made with bituminous coal ; but for castings, the latter may be often used with advantage.

Pig iron, according to the proportion of carbon which it contains, is divided into *foundry iron* and *forge iron*, the latter being adapted only to converting into

malleable iron, while the former, containing the largest proportion of carbon, can be used either for casting or for making bar iron.

Malleable Iron.

Malleable iron may be made directly from the pigs, by means of the bloomery, or puddling furnace; but when it is desired to obtain iron homogeneous and of the best quality, the pig iron should invariably be *refined*, otherwise, the bar iron will be full of black specks and cinder holes.

REFINING. This important operation deprives the iron of a considerable portion of its carbon; it is effected in a *blast furnace* where the iron is melted by means of charcoal or coke, and exposed for some time to the action of a great heat; the metal is then run into a cast iron mould, by which it is formed into a large, broad plate, about 2.5 in. thick. As soon as the surface of the plate is chilled, cold water is poured on plentifully, to render it brittle.

The next process is to convert the metal into malleable iron, by depriving it of its remaining carbon and oxygen, which in the United States is usually effected in the *bloomery fire*; in England, by means of a *puddling furnace*.

BLOOMERY. The bloomery resembles a large forge fire, where charcoal and a strong blast are used, and the refined metal or the pig iron, after being broken into pieces of the proper size, is placed before the blast, directly in contact with the charcoal; as the metal fuses, it falls into a cavity left for that purpose below the blast, where the bloomer works it into the shape of a *ball*, which he places again before the blast, surrounded with fresh charcoal; this operation is generally again repeated, when the ball is ready for the *shingler*.

PUDDLING, is effected in a reverberatory furnace, where the flame of bituminous coal is made to act directly on the metal, which has been previously broken into small pieces. When melted, it is thoroughly worked by the puddler, who separates his charge, on the cast iron bottom or hearth of the furnace, into five or six *puddlers' balls*, weighing from 80 to 100 pounds each. These balls are next passed to the shingler.

SHINGLING, is best performed under the *tilt hammer* weighing from two to four tons, although it is sometimes done under a *squeezer*; it has a double object, to form the ball into a shape to be received by the puddle rolls, and to express the liquid cinder which may remain in the ball; this is effected by from fifteen to twenty blows with the hammer; the ball, now called a *bloom*, is ready for being rolled or hammered.

PUDDLE ROLLS. By passing through different grooves in these rolls, the bloom is reduced to a *rough bar* from three to four feet in length, its name conveying an idea of its condition, which is rough and imperfect.

The bloom may be *broken down* under the hammer, instead of rollers; for this purpose, the shingler works the bloom as long as the heat will permit, when it is re-heated and hammered, until it is reduced to one or more *anconies*, according to the size of bar which it is intended to make; these are again heated and reduced to the required size and shape.

PILING. To prepare rough bars for this operation, they are cut, either hot or cold, by means of a strong pair of *shears*, into such lengths as are best adapted to the size of the finished bar required; the sheared bars are piled, one over the other, to the number of from two to six or more pieces, according to the size required, when the pile is ready for

BALLING. This operation is performed in the balling furnace, which is similar to the puddling furnace, except that its bottom or hearth is made up, from time to time, with sand instead of cast iron; it is used to give a welding heat to the piles to prepare them for rolling.

FINISHING ROLLS. The *balls* are passed successively between rollers of various forms and sizes according to the shape of the finished bar required.

These bars are straightened on a cast iron bed, with heavy wooden beetles.

PROPERTIES OF IRON. All iron contains more or less carbon, the hardest containing the least, and the proportion varies from $\frac{1}{2}$ to 2 per cent. It melts at 160° Wedgewood; it expands 1-812th from 0° to 212° Fahr., and 1-140th part, from 0° to a red heat—Specific gravity 7,788.

To test the quality of bar iron. The most convenient test is by the fracture; but this is not always sufficient, as the same iron will present different appearances according to the manner in which it has been forged, and the degree of heat to which it has been subjected. In testing by the fracture, the sample should be 1 inch square, or if a flat bar, $\frac{1}{2}$ inch thick; cut a notch on one side with a cold chisel, and bend the bar down over the edge of an anvil, or give it a heavy blow, when laying flat, on the ground, with a sledge hammer; if the fracture exhibits long silky fibres, of a leaden grey color, cohering together and twisting or pulling apart before breaking, it denotes a tough, soft iron which is easy to work and hard to break, suitable for sheet iron, wire, &c., but it may weld badly. A medium, even grain, mixed with fibres as above, but without bright specks or dark spots, is also a favorable indication. In general, a short, blackish fibre indicates iron badly refined and mixed with carbon, plumbago or oxide; if worked very hot, it may be improved, but there will be a great waste. A *very fine, close grain*, denotes a hard, steely iron, which is apt to be *cold short*, hard to work with the hammer or file. A *coarse grain*, with a brilliant, crystallized fracture, or yellow or brown spots, denotes a brittle iron, in-

clined to be *cold-short*, but working easily when heated, and making a good weld. Numerous cracks on the edges of the bar generally indicate a *hot-short* iron, which cracks or breaks when punched or worked at a red heat, and will not weld; it is strong when cold, and may be useful in that state, but if worked, care should be taken not to subject it to strains at a red heat. *Blisters, flaws, and cinder holes*, are caused by imperfect welding at too low a heat, or by the iron not being properly worked, and do not always indicate an inferior quality. The abovementioned characters are not often found separate in iron, and its quality must be determined by their combination, and by the predominance of one or the other of them. In general, good iron is readily heated, is soft under the hammer, and throws out but few sparks when taken from the fire.

The best test for iron is to have a piece forged into the shape in which it is intended to use it. *Another test for iron when cold* is to cut a screw thread on a square bar, and bend it by striking the end with a hammer; also by punching or drilling pieces which are to have holes in them; in the case of the square bar, it should be bent in different directions at sharp angles, and if the bar is heavy, place the end on the corner of the anvil and strike it with a heavy sledge until the piece is forced off. Examine the welding of pieces which are *jumped on, or upset*.

To test iron when hot. Draw out the iron, bend and twist it—split it, and turn back the two parts, to see if the split extends up—punch a long hole in the direction of the fibre and another at right angles to it—punch holes of different forms—weld the iron to iron and steel—make chains from small rods—observe if cracks or flaws weld easily—finally, forge some of the most difficult pieces for which the iron is intended.

NOTE ON FORGING. Good iron is often injured by being unskilfully worked; care should be taken that the iron while heating, is not exposed to the air, which would assist in forming scales of oxide on its surface. It is to prevent this that the workman from time to time throws sand or clay on his iron to protect it. When iron is at a white heat, immediate contact with coal tends to carbonize it and make it *steely*. Iron heated for any purpose, and especially for welding, should be heated as rapidly as possible, in order to expose it the least possible time to the action of the air and coal; for this purpose the strongest fuel, with an abundant, steady blast, is necessary. Defects in iron, caused by unskilful working may be remedied in part—if, for example, iron has been *burned*, give it a smart heat, protected as much as possible from the air—if the iron has been injured by *cold hammering*, a moderate annealing heat will restore it—if the iron has become hard and steely, give it one or more smart heats, to extract the carbon.

CAST IRON.

Iron castings for ordnance purposes are made of the pig metal obtained from the smelting furnace. There are many varieties of cast iron, differing from each other by almost insensible shades; the two principal divisions are *grey* and *white*, so called from the color of the fracture when recent.

Grey iron, is softer and less brittle than white iron; it is in a slight degree malleable and flexible, and is not sonorous; it can be easily drilled and turned in the lathe, and does not resist the file. It has a brilliant fracture, of a grey, or sometimes a bluish grey color; the color is lighter as the grain becomes closer, and its hardness increases at the same time. A coarse grain, without much lustre, indicates a good quality of grey metal; a small, white, shining grain, the contrary: Its mean specific gravity is 7,200.

Grey iron melts at a higher heat than white iron, becomes more fluid, and preserves its fluidity longer; it runs smoothly; the color of the fluid metal is red, and it is deeper in proportion as the heat is lower; it does not stick to the ladle; it fills the moulds well, contracts less and contains fewer cavities than the white iron; the edges of a casting are sharp and the surface smooth, convex, and covered with carburet of iron. Grey iron is the only kind suitable for making castings which require great strength, such as cannon. Its tenacity is increased by annealing at a red heat; but at a white heat it becomes brittle, and acquires a permanent increase of bulk.

White iron is very brittle and sonorous; it resists the file and the chisel, and is susceptible of a high polish; the surface of a casting is concave; the fracture presents a silvery appearance, generally fine grained and compact, sometimes radiating, or lamellar. Its mean specific gravity 7,500.

When melted it is white, and throws off a great number of sparks, and its qualities are the reverse of those of grey iron; it is therefore unsuitable for ordnance purposes.

Mottled iron is a mixture of white and grey; it has a spotted appearance; it flows well and with few sparks; the casting has a plane surface, with edges slightly rounded. It is suitable for making shot and shells.

Besides these general divisions the manufacturers distinguish more particularly the different varieties of pig metal by numbers, according to their relative hardness.

No. 1 is the softest iron, possessing in the highest degree the qualities described as belonging to grey iron; it has not much strength, but on account of its fluidity when melted and of its mixing advantageously with old or scrap iron, and with the harder kinds of cast iron, it is of great use to the founder, and commands the highest price.

No. 2 is harder, closer grained and stronger than No. 1 ; it has a grey color and considerable lustre. It is the kind of iron most suitable, in general, for making shot and shells.

No. 3 is still harder than No. 2. Its color is grey, but inclining to white ; it has considerable strength, but it is principally used by the founder for mixing with other kinds of iron.

No. 4 is *bright* iron. No. 5, *mottled*. No. 6, *white*, which is unfit for general use by itself.

The qualities of these various kinds of iron seem to depend on the proportion of carbon, and on the state in which it is found in the metal. In the darker kinds of iron, where the proportion is sometimes 7 per cent. of carbon, it exists partly in the state of graphite or plumbago, which makes the iron soft. In white iron, the carbon is thoroughly combined with the metal, as in steel.

Cast iron frequently retains a portion of foreign ingredients from the ore, such as earths, or oxides of other metals, and sometimes sulphur and phosphorus, which are all injurious to its quality. Sulphur hardens the iron, and unless in a very small proportion, destroys its tenacity.

These foreign substances, and also a portion of the carbon, are separated by melting the iron in contact with air, and soft iron is thus rendered harder and stronger. The effect of remelting varies with the nature of the iron and the kind of ore from which it has been extracted ; that from the hard ores, such as the magnetic oxides, undergoes less alteration than that from the hematites ; the latter being sometimes changed from No. 1 to *white* by a single remelting in the air furnace. The kind of iron most suitable for any special purpose, such as the casting of cannon, should be ascertained by trial for that purpose in the furnace in which it is to be used.

All cast iron expands forcibly at the moment of becoming solid, and again contracts in cooling ; grey iron, as before remarked, expands more and contracts less than other iron,

The color and texture of cast iron depend greatly on the size of the casting and the rapidity of cooling ; a small casting, which cools quickly, is almost always *white*, and the surface of large castings partakes more of the qualities of white metal than the interior,

STEEL.

Steel is a compound of iron and carbon, in which the proportion of the latter is from 5 to 1 per cent., and even less, in some kinds. Steel may be distinguished from iron by its fine grain ; its susceptibility of hardening by immersion, when hot, into cold water ; and with certainty, by the action of dilute nitric acid, which leaves a black spot on steel, and on iron a spot which is lighter colored in proportion as the iron contains less carbon.

There are many varieties of steel, the principal of which are :

Natural steel, which is obtained by reducing the rich and pure kinds of iron ore with charcoal, and refining the cast iron, so as to deprive it of a sufficient portion of carbon to bring it to a malleable state. It is made principally in Germany and is used for making files and other tools.

The India steel called *Wootz* is said to be a natural steel, containing a small portion of other metals.

Blistered steel, or steel of cementation, is prepared by the direct combination of iron and carbon. For this purpose, the iron in bars is put in layers alternating with powdered charcoal, in a close furnace, and exposed for 7 or 8 days to a heat of about 70° Wedgwood, and then suffered to cool for as many days more. The bars on being taken out are covered with blisters, have acquired a brittle quality, and exhibit in the fracture a uniform crystalline appearance. The degree of carbonization is varied according to the purposes for which the steel is intended, and the best qualities of iron (Russian and Swedish) are used for the finest kinds of steel.

Tilted steel, is made from blistered steel moderately heated and subjected to the action of a tilt hammer, by which means its tenacity and density are increased, and it is thus adapted to use.

Shear steel, is made from blistered or natural steel refined by piling thin bars into faggots, which are brought to a welding heat in a reverberatory furnace, and hammered or rolled again into bars; this operation is repeated several times to produce the finest kinds of shear steel, which are distinguished by the names of *half-shear*, *single-shear*, and *double-shear*, or steel of 1 *mark*, of 2 *marks*, of 3 *marks*, &c., according to the number of times it has been piled.

Cast steel, is made by breaking blistered steel into small pieces and melting it in close crucibles from which it is poured into iron moulds; the *ingot* is then reduced to a bar by hammering or rolling, as described under the head of malleable iron, these operations being performed with great care. Cast steel is the finest kind of steel and best adapted for most purposes; it is known by a very fine, even and close grain, and a silvery homogeneous fracture; it is very brittle and acquires extreme hardness, but is difficult to weld without the use of a flux. The other kinds of steel have a similar appearance to cast steel, but the grain is coarser and less homogeneous; they are softer and less brittle, and weld more readily. A fibrous or lamellar appearance in the fracture indicates an imperfect steel. A material of great toughness and elasticity, as well as hardness, is made by forging together steel and iron, forming the celebrated *damask steel*, which is used for sword blades, springs, &c.; the damasked appearance is produced by the action of a diluted acid, which gives a black tint to the steel parts, whilst the

iron remains white. Various *fancy steels*, or alloys of steel with *silver, platina, rhodium, aluminium*, have been made with a view to imitating the Damascus steel, wootz, &c., and improving the fabrication of some of the finer kinds of surgical and other instruments.

PROPERTIES OF STEEL. The best steel possesses the following characters: heated to redness and plunged into cold water, it becomes hard enough to scratch glass, and to resist the best files; the hardness is uniform throughout the piece; after being tempered it is not easily broken; it welds readily; it does not crack or split; it bears a very high heat and preserves the capability of hardening after repeated working; the grain is fine, even, and homogeneous, and it receives a brilliant polish. Its specific gravity is 7,816, being greater than that of iron.

Test. Break a few bars, taken at random; make tools of them and try them in the severest manner.

HARDENING AND TEMPERING STEEL. On these operations the quality of manufactured steel in a great measure depends.

Hardening, is effected by heating the steel to a cherry red, or until the scales of oxide are loosened on the surface, and plunging it into a liquid, or placing it in contact with some cooling substance; the degree of hardness depends on the heat and the rapidity of cooling. Steel is thus rendered so hard as to resist the hardest files, and it becomes at the same time extremely brittle. The degree of heat and the temperature and nature of the cooling medium must be chosen with reference to the quality of the steel and the purpose for which it is intended. Cold water, mercury and acids give the greatest hardness; oils and fatty substances, sand, wet iron scales or cinders, &c., give an inferior degree of hardness, but prevent the cracks which are caused by too rapid cooling. The lower the heat at which the steel becomes hard, the better.

Tempering. Steel in its hardest state being too brittle for most purposes, the requisite strength and elasticity are obtained by tempering, or *letting down the temper*, as the workmen term it, which is performed by heating the hardened steel to a certain degree and letting it cool gradually. The requisite heat is usually ascertained by the color which the surface of the steel assumes from the film of oxide thus formed. The degrees of heat to which these several colors correspond, are as follows:

At 430° Fahr., a very faint yellow.	} Suitable for hard instruments; as hammer faces, drills for hard substances, &c.
At 450° " a pale straw color.	
At 470° " a full yellow.	} For instruments requiring hard edges without elasticity; as shears, scissors, tools for turning iron and steel.
At 490° " a brown color.	

At 510° Fahr., brown, with purple spots.	-	-	} For tools for cutting wood and soft metals ; such as plane irons, chisels, knives, &c.
At 530° “ purple.	-	-	
At 550° “ dark blue.	-	-	} For tools requiring strong edges without extreme hardness; as cold chisels, axes, table cutlery, &c., which will break before bending.
At 560° “ full blue.	-	-	
At 600° “ greyish blue, verging on black.	-	-	} For spring temper, which will bend before breaking ; saws, sword blades, &c.

If the steel is heated higher than this, the effect of the hardening process is destroyed.

CASE HARDENING, is the conversion of the surface of wrought iron into steel, for the purpose of adapting it to receive a polish, or to bear friction, &c. ; this is effected by heating the iron to a cherry red, in a close vessel, in contact with carbonaceous materials, and then plunging it into cold water. Bones, leather, hoofs and horns of animals, are generally used for this purpose, after having been burnt or roasted, so that they can be pulverized. Soot is also frequently used.

SHEET IRON.

Sheet iron is made by rolling. It should be soft and tough, its surface very smooth, without holes or thick scales ; it is generally of a bluish color, sometimes clouded; the sheet should be of regular thickness, elastic, and crackling when bent in the hands. When bent at a right angle, there should be no appearance of fracture on the exterior.

Russia sheet iron has a planished, glossy and smooth surface of grey oxide of iron ; it should be free from rust or flaws, and be very soft and tough.

The severest test of sheet iron consists in hammering a part of the sheet into a concave form.

Sheet steel, should have the same qualities as sheet iron, with greater elasticity and hardness in a thinner sheet.

For the weight of sheet iron, see TABLES in Chapter 16.

SHEET TIN.

Sheet tin is made by coating sheet iron with tin. The iron is first *scoured*, or thoroughly cleaned, by means of an acid, and then immersed in melted tin. There are two kinds, called *single tin* and *double tin*, differing in thickness and in the quantity of tin with which the iron is coated. The surface of the sheets should be bright and smooth, free from specks, beads and blisters.

KIND OF TIN.	Size of sheet.	MEAN THICKNESS.		Mean weight of one sheet.	REMARKS.
		No. on wire gauge.	Thickness of sheet		
	In.		In.	lbs.	
Single Tin	10 × 14	31	0.0125 or 80 to 1 in.	0.5	There are usu- ally 225 sheets in a box.
Double X	10 × 14	27	0.018 or 55 to 1 in.	0.75	

FILES AND RASPS.

List of Files and Rasps required for use at an Arsenal of Construction.

No.	KIND.	Length.	Width.	Thick- ness.	Weight.		REMARKS.
		In.	In.	In.	lbs.	oz.	
1	Flat rough (ruffs) -	14.	1.35	0.35	1	4	Flat, tapering towards the point.
2	Do. do. -	12.	1.17	0.3	0	15	
3	Do. bastards -	12.	1.17	0.3	0	14	
4	Do. do. -	8.	0.7	0.2	0	5	
5	Half round bastards	12.	1.14	0.32	0	11	
6	Do. do. -	9.	0.85	0.25	0	5½	
7	Do. do. -	6.	0.56	0.2	0	1½	
8	Round do. -	12.	—	0.5	0	8½	
9	Do. do. -	9.	—	0.33	0	2	
10	Do. do. -	6.	—	0.23	0	¾	
11	Do. do. -	4.5	—	0.16	0	¼	
12	Square do. -	12.	0.5	0.5	0	9	
13	Do. do. -	8.	0.32	0.32	0	3	
14	Do. do. -	6.	0.24	0.24	0	2	
15	Do. do. -	4.	0.2	0.2	0	¾	
16	Flat, single cut, (floats) -	12.	1.12	0.22	0	10½	1 edge round'd.
17	Flat, hand, smooth	12.	1.16	0.31	1	2	Safe edge.
18	Do. do.	9.	0.96	0.27	0	10	Do.
19	Do. do.	8.	0.83	0.2	0	6	Do.
20	Do. do.	4.	0.44	0.1	0	¾	Do.
21	Half round, hand, do.	12.	1.15	0.33	0	12	
22	Do. do.	9.	0.84	0.27	0	5½	
23	Do. do.	6.	0.6	0.18	0	1½	
24	Taper, hand saw, -	4.5	△	0.4	0	1¼	
25	Flat shoeing rasp -	14.	1.5	0.35	1	8	Without tang.
26	Half round do. -	12.	1.14	0.32	0	11	

English files are used exclusively at the Arsenals and Armories.

Files should be made of the best cast steel. The teeth are generally cut at an angle of 60° with the centre line; at a smaller angle, the teeth are apt to choke, and at a greater angle, they do not cut.

In choosing files, they should be examined to see that they are straight, that they are free from cracks and flaws, and that they are cut regularly. The teeth should not be turned or broken by filing on iron or tempered steel. One out of each dozen may be tried on a piece of tempered steel, such as the tang of a file screwed in a vice; the file should "take" in its whole length, both on the flat and edge, and should not cut in drawing back; it should not make furrows, or show a tendency to deviate from the direction given to it by the hand. The quality of the steel may be determined by breaking some of the files, and working the steel in the forge.

STORAGE AND PRESERVATION OF METALS.

Metals are stored on the ground floors of dry and well aired buildings, which should be kept open in fine weather only.

Bar iron and *steel*, and pieces rough forged, (*shapes*,) divided according to kind and size, on racks, or standing upright in frames—*unservicable iron* and *scraps*, in piles marked with the weight. *Sheet iron* and *tin*, oiled, and placed on edge, in frames. *Wire*, oiled, in coils, hung on hooks; arranged according to kind and size.

Heavy chains, coiled up in piles—*Small chains*, in bundles of 10 or 20, in boxes or on shelves.

Finished work, according to kind, in piles or in boxes.

Pig metal, in square piles; the flat sides lying together.

The iron and steel parts of implements, &c., covered with a black varnish, made of white varnish and lampblack, for intrenching, and other heavy tools; of white varnish and ivory black, for polished tools. See Chapter 13.

Artificers' tools and *files*, according to kind, in a dry place, with suitable divisions; they should be sprinkled with powdered charcoal, or fine quick lime, to protect them from rust.

Nails, according to kind and size, in bins. *Anvils* and other heavy pieces, on skids on the floor. Every division, bin, pile and box, should be marked with a label showing the character of the article contained in it, its kind, its distinctive number or size, the quantity, weight, &c.

COAL.

Charcoal.

Charcoal of good quality burns slowly in the air, without flame; it is clean, hard, compact, brittle, sonorous, and of a fine black colour, its fracture is shining, iridescent, and of a conchoidal form.

When not perfectly charred, it is tough, of a greyish colour, and burns with a white flame and smoke. When too much burnt, it is of a dull black, soft and unelastic. By exposure to the air, charcoal absorbs from 10 to 20 per cent. of moisture, and its qualities are thereby impaired; it should therefore be kept under cover.

Charcoal is made from either hard or soft wood; that from the former, such as oak, maple, beech, chesnut, is the most serviceable, giving the greatest quantity of heat for an equal weight of coal.

Making charcoal. For ordinary purposes, wood is charred in heaps or stacks, in the following manner: Select sound wood; it may be burnt immediately after being felled; wood which has been exposed for a year after felling gives inferior charcoal. Cut it into pieces about 4 or 5 feet long, and split those which are more than 4 inches in thickness.

Level the ground on which the stack is to be made, choosing a dry and sheltered spot. Plant a stake in the middle of the space, and cover the bottom of the pile with wood placed in a direction converging towards the centre, the intervals being filled up with small sticks; place the rest of the wood around the stake, the pieces nearly upright and close together, in several tiers, covering the whole with a layer of wood placed as close together as possible; leave one or more horizontal openings near the ground, from the exterior to the centre. Cover the stack, commencing at the top, with leaves and a coat of wet sod about 4 inches thick, leaving open a space 6 inches high, all round the bottom, for the escape of the air and steam.

Draw out the stake, and set fire to the pile, either by means of the hole left by the stake, or through the horizontal gallery, which may have been previously filled with combustible materials. Push the fire actively until the flame comes out at the top of the stack, in order to ignite the whole of the bottom part, and to expel the steam which would otherwise occasion explosions. Then close the hole at the top, and cover the lower part of the pile, leaving small openings at intervals; the smoke should now escape equally from all parts of the stack, except towards the top, which is kept closed in order to prevent a draught. When the stack has *sweated* sufficiently, increase the thickness of the coating of earth; moderate the fire, and direct it, by means of openings on the sides, in

such a manner that the combustion may be equal in every part, and that the fire may be always drawn towards the bottom. Leave the holes open as long as the smoke is black and thick, and close them when it becomes light and of a bluish color. The charring is completed when the flame escapes through the openings at the bottom; then stop the holes and cover the pile well with earth, which should be renewed after 24 hours; extinguish the fire entirely, and let the pile stand 12 or 24 hours more. Open it on one side only; select the coal, and separate what is imperfectly burnt. Wood furnishes in this way, on an average, about 16 or 17 per cent. of charcoal.

The stack should be formed of one kind of wood; if soft and hard woods are used in the same pile, put the former on the outside. Large stacks are the most advantageous; as much as 50 or 60 cords of wood may be put into one.

Pit Coal.

BITUMINOUS COAL. There are two principal varieties:

Open burning coal kindles quickly and burns well, but produces much flame and smoke, and is soon consumed; it lies open in the fire and does not cake. Of this kind is the English cannel coal.

Close burning coal melts and swells in the fire and runs together, forming what blacksmiths call a *hollow fire*, or a dome over the nozzle of the bellows, under which the iron is heated equally, and covered from the air. This kind of coal forms a very hot fire and leaves little residuum; it is, therefore, the most suitable for smiths' use. The Newcastle coal, and the Virginia and Pennsylvania bituminous coals are of this kind.

ANTHRACITE COAL, is now extensively used for the forge; it ignites with difficulty, and does not cake or melt in the smallest degree, but produces a very hot, open fire.

Coal is not injured, but on the contrary rather improved, by exposure to air and moisture.

Coke.

Coke is produced by charring bituminous coal, in order to expel the bitumen and sulphur; this is usually done in close furnaces or ovens. Good coke has a dull fracture, is very porous, and cellular; it gives very little ashes when burnt; it is injured, like wood charcoal, by absorbing water.

Coal furnishes 60 to 70 per cent. of coke by weight; the volume being increased 5 to 15 per cent.

ROPES.

The size of a rope is designated by the circumference or girth, measured with a thread; thus, a 3-inch rope measures 3 inches round. The length is usually expressed in fathoms.

STRENGTH. The utmost strength of good hemp rope, is 6,400 lbs. to the square inch; the weight which it will bear before breaking is expressed in *tons* by *one-fifth of the square of the girth in inches*; in practice, a rope should not be subjected to more than half this strain. It stretches from 1-7th to 1-5th, and its diameter is diminished from 1-7th to 1-4th, before breaking. A difference in the quality of the hemp may produce a difference of 1-4th in the strength of ropes of the same size.

White rope is stronger than tarred rope, and the difference is increased by age and service; therefore such ropes only as are to be immersed in water should be tarred.

QUALITY. The quality of hemp is in some measure indicated by its color; the best is of a pearl grey; the next, greenish; then, the yellow; a brown color indicates the beginning of decay; the odour should be strong, but free from a musty, tainted smell. It should be well combed, pliant, and clear of stalks. The yarns should be fine spun and slightly twisted; they are from $\frac{1}{4}$ to $\frac{1}{3}$ of an inch in girth. A rope is defective when the yarns are of unequal sizes, or unequally twisted; when it is fuzzy before being used; and when it contains pieces of stalk, indicating that the hemp was not well combed.

TWISTING OR LAYING. The number of *yarns* in a *strand* of cordage varies from 16 to 25, and several strands are combined or *laid*, to form a large rope. A rope is said to be twisted $\frac{1}{3}$ or $\frac{1}{4}$, when it is $\frac{1}{3}$ or $\frac{1}{4}$ shorter than the strand. For artillery service, ropes should be twisted $\frac{1}{4}$.

The degree of twisting may be determined by constructing a right-angled triangle, the base of which is the circumference of the rope, and the height, the length of one revolution of the strand, measured parallel to the axis; the difference between this height and the hypotheneuse is the quantity by which the rope is twisted.

SPLICING, is the joining of two ends of rope without a knot; the instrument used for the purpose is a *marline spike*. There are two kinds of splice; see *Plate 15*.

Short splice. Untwist from 4 to 8 inches of each of the two ends of rope, and interlock the strands up to the close parts of the rope, those of the two ends alternating; hold in the left hand one end of rope with the loose strands in

front, and cross each strand of that end over the strand of the other end which is to the left hand of it; then by means of the marline spike, pass it under the same strand of the second end, and draw firmly on the strand which is passed through. Pursue the same course with the strands of the second rope. To increase the strength of the splice, pass each strand round the one on its left a second time, and cut off the loose ends.

Long splice. For a rope which is to pass through a pulley, the short splice would be too thick. Untwist about 18 inches of the two ends, and interlock them as before; untwist a strand of one end from the close part of the rope and replace it by the strand of the other rope which comes to hand; cross the end of the latter strand over the one which is replaced, and pass it under the adjacent strands. Substitute in this manner, every other strand of one rope by a strand of the other rope, and cut off the loose ends.

PRESERVATION IN STORE. Ropes should be placed in the upper stories of a building, coiled up and labeled; large ropes on skids, so as to allow the circulation of air; small ropes hung up to the joists, on pins or hooks. Ropes should not be coiled until they are perfectly dry; they should be uncoiled every year, and stretched out for several days at the beginning of the dry season.

TAR, PITCH, TURPENTINE.

The following are the principal varieties of products from resinous trees, such as the pine.

TURPENTINE. This is extracted from the tree in warm weather, by cutting a deep notch, or *box*, near the base, and scoring the tree by scraping off the bark above the box; the first year's running produces the *virgin* or *white turpentine*, and the second year's is nearly as good; after that, the turpentine becomes each year darker and stiffer, the tree yielding less of what is called *dippings*, and more *scrapings*; the latter kind of turpentine is hard and yellow. A tree will bear tapping 14 to 16 years, on two sides alternately, the scoring being extended upwards from 12 to 15 inches each year.

SPIRITS OF TURPENTINE, is the *essential oil* obtained by distillation from the native turpentine.

ROSIN, OR COLOPHONY, is the residuum of the distillation of turpentine. Its quality depends on that of the turpentine and on the care used in distillation; the finest quality is of a light straw colour.

TAR is obtained from the heart of the pine tree, by *smouldering*, or a smothered combustion, effected in stacks, nearly in the manner described for making charcoal. The tar runs off into trenches dug for the purpose. Tar is semi-fluid,

transparent in thin portions, and of a reddish colour; it has a strong, peculiar odour. It is rendered more fluid by heat; and it burns with a bright flame, leaving a light and dry coal. It is refined by heating it in an iron vessel, and pouring it off, after it has been kept for some time in a liquid state; by this means, water and pyroligneous acid are driven off, and the earthy particles are separated by settling.

It is used for coating cordage, and for wood which is not to be immersed in water.

PITCH, is made by boiling tar down to the requisite consistency, either by itself or combined with a portion of rosin; it becomes solid on cooling, but is soon softened by the heat of the hand, in which state it is very adhesive; when of good quality it is clear and hard.

It is used for coating wood which is to be immersed in water, and is applied hot, with a *mop*.

VENICE TURPENTINE is obtained from the *larch*, but what is commonly called by that name is a compound of melted rosin and spirits of turpentine.

CHAPTER THIRTEENTH.

PAINTS, LACKERS, ETC.

COMPOSITION AND PREPARATION.

The proportions are given for 100 parts by weight of prepared colors, &c., when not otherwise designated.

NOTE. A gallon of linseed oil weighs 9 lbs.; of spirits turpentine, 8.5 lbs.

Boiled Oil.

Raw linseed oil	-	-	-	103
Copperas	-	-	-	3.15
Litharge	-	-	-	6.3

Put the copperas and litharge in a cloth bag and suspend it in the middle of the kettle. Boil the oil $4\frac{1}{2}$ hours, with a slow, even fire, so that it may not be burnt; then let it stand and deposit the sediment.

Dryings.

Mixture of copperas and litharge taken from the boiled oil - 60

Spirits turpentine - - - - 56

Boiled oil - - - - 2

The mixture taken from the boiled oil to be ground, and mixed with the turpentine and oil.

Putty.

For filling cracks in wood:

Spanish whiting, pulverized - - 81.6

Boiled oil - - - - 20.4

Made into a stiff paste. If not intended for immediate use, raw oil should be used, as the putty made with boiled oil hardens quickly.

White Paint.

For inside work.

For outside work.

White lead, ground in oil - 80 - - 80

Boiled oil - - - 14.5 - - 9

Raw oil - - - - - - 9

Spirits turpentine - - - 8 - - 4

Grind the white lead in the oil, and add the spirits of turpentine.

New wood work requires about 1 lb. to the square yard, for 3 coats.

Lead color.

White lead, ground in oil	-	75.
Lampblack	-	1.
Boiled linseed oil	-	23.
Litharge	-	0.5
Japan varnish	-	0.5
Spirits turpentine	-	2.5

The lampblack and the litharge are ground separately upon the stone, in oil, then stirred into the white lead and oil; the turpentine and varnish are added as the paint is required for use, or when it is packed in kegs for transportation.

Grey, or Stone Color, (for Buildings.)

White lead, in oil	-	78.
Boiled oil	-	9.5
Raw oil	-	9.5
Spirits of turpentine	-	3.
Turkey umber	-	0.5
Lampblack	-	0.25

Mixed like the lead color.

1 Square yard of new brick work requires, for 2 coats, 1.1 lb.; for 3 coats, 1.5 lb.

Cream Color, (for Buildings.)

	1st coat.	2d coat.
White lead, in oil	66.66	70.
French yellow	3.33	3.33
Japan varnish	1.33	1.33
Raw oil	28.	24.5
Spirits turpentine	2.25	2.25

1 Square yard of new brick work requires for 1st coat, 0.75.; for 2d coat, 0.3 lb.

Black Paint.

Lampblack	-	28.
Litharge	-	1.
Japan varnish	-	1.
Linseed oil, boiled	-	73.
Spirits turpentine	-	1.

Grind the lampblack in oil ; mix it with the oil, then grind the litharge in oil and add it, stirring it well into the mixture. The varnish and turpentine are added last. This paint is used for the iron work of carriages.

Olive Paste.

Yellow ochre, pulverized	-	68.
Lampblack	-	1.1
Boiled oil	-	37.
Spirits turpentine	-	0.4

Make a thick paste with the ochre and oil, in a paint pot, and with the lampblack and oil in another ; grind them together in small portions, and keep the mixture in a tin vessel.

Liquid Olive Color.

Olive paste	-	61.5
Boiled oil	-	29.5
Spirits turpentine	-	5.5
Dryings	-	3.5
Japan varnish	-	2.

Stirred together in a paint pot.

Quantity of Paint required for a Carriage.

KIND OF CARRIAGE.	Lead color.	Olive.	Black.
	lbs.	lbs.	lbs.
Field gun carriage and limber, with implements	6	10.	0.75
Caisson, with limber and implements, &c.	8	15.	0.8
Forge, with limber	6	10.	1.
Battery wagon, do.	7	13.	0.9
Casemate carriage and chassis, with implements	7	14.	0.75
Barbette carriage and chassis, with implements	6	11.	1.

A priming of lead color and two coats of olive color are applied to new wood work, and 1 coat of lead color and 1 of black, to the iron work.

Paint for Tarpaulins.

1 Square yard takes 2 lbs. for 3 coats.

1.—Olive.—Liquid olive color	-	100
Beeswax	-	6
Spirits turpentine	-	6
35		

Dissolve the beeswax in the spirits of turpentine, with a gentle heat, and mix the paint warm.

2.—Add 12 oz. of beeswax to 1 gallon of linseed oil and boil it two hours; prime the cloth with this mixture, and use the same, in place of *boiled oil*, for mixing the paint. Give two coats of paint.

Lacker for Iron Ordnance.

1.—Black lead, pulverized	-	-	12
Red lead	-	-	12
Litharge	-	-	5
Lampblack	-	-	5
Linseed oil	-	-	66

Boil it gently about twenty minutes, during which time it must be constantly stirred.

2.—Umber, ground	-	-	3.75
Gum shellac, pulverized	-	-	3.75
Ivory black	-	-	3.75
Litharge	-	-	3.75
Linseed oil	-	-	78.
Spirits of turpentine	-	-	7.25

The oil must be first boiled half an hour. The mixture is then boiled 24 hours, poured off from the sediment and put in jugs corked.

3.—*Coal Tar*, (of good quality.)

In applying lacker, the surface of the iron must be first cleaned with a scraper and a wire brush, if necessary, and the lacker applied hot, in two thin coats, with a paint brush. It is best done in summer.

Old lacker should be removed with a scraper, or by scouring, and not by heating the guns or balls, by which the metal is injured.

About 5 gallons of lacker are required for 100 field guns and 1,000 shot; about 1 quart for a sea-coast gun.

Lacker for Iron Ordnance, (used in the British service.)

Anticorrosion	-	-	40 lbs.
Grant's black, ground in oil	-	-	4 "
Red lead, as a dryer	-	-	3 "
Linseed oil	-	-	4 gals.
Spirits turpentine	-	-	1 pint.

This mixture when well stirred and incorporated, will be fit for use; but as by

long keeping in this state it becomes hard, no more should be mixed than may be required for immediate use.

Anticorrosion :

Slag from iron foundries, pounded	12
Chalk - - -	12
Soot, common - - -	1

Lacker for Small Arms, or for Water Proof Paper.

Beeswax - - -	18
Spirits turpentine - - -	80
Boiled linseed oil - - -	3.5

All the ingredients should be pure and of the best quality. Heat them together in a copper or earthen vessel, over a gentle fire, in a water bath, until they are well mixed.

Lacker for bright Iron Work.

Linseed oil, boiled - - -	80.5
Litharge - - -	5.5
White lead, ground in oil - - -	11.25
Rosin, pulverized - - -	2.75

Add the litharge to the oil; let it simmer over a slow fire 3 hours; strain it, and add the rosin and white lead; keep it gently warmed, and stir it until the rosin is dissolved. Apply it with a paint brush.

Varnish for Holsters, Scabbards, &c., (or Patent Leather.)

For 1st and 2d coats :

Prussian blue, in lumps - - -	4.
Sugar of lead - - -	0.7
Aqua fortis - - -	0.7
Linseed oil, boiled - - -	70.
Spirits turpentine - - -	24.6

The ingredients, except the turpentine, are boiled together in an iron kettle 8 hours, when the mixture will assume a brilliant black color. When the varnish is nearly cool, stir in the turpentine. The kettle in which the varnish is made should be of a capacity to hold double the quantity of varnish to be boiled.

For the 3d, or finishing coat.—COPAL VARNISH.

Gum copal, (in clean lumps) - - -	26.5
Boiled linseed oil - - -	42.5
Spirits turpentine - - -	31.

This varnish is made in a *copper* vessel, smallest at top, in the form of a still.

Put the copal in the vessel, set it on a charcoal fire for one hour, in which time it will melt, and all the watery particles will evaporate. Add the oil whilst the copal is warm, but not boiling hot. When nearly cool, add the turpentine, which will give it a proper consistency for use.

For 5 lbs. copal and the proper proportions of oil and turpentine, the vessel should hold six gallons.

Japan Varnish.

Litharge	-	-	-	4
Boiled oil	-	-	-	87
Spirits turpentine	-	-	-	2
Red lead	-	-	-	6
Umber	-	-	-	1
Gum shellac	-	-	-	8
Sugar of lead	-	-	-	2
White vitriol	-	-	-	1

Japan varnish is generally purchased from the paint sellers. It is made by boiling over a slow charcoal fire, for five hours, all the ingredients, except the turpentine and a small portion of the oil; the latter is added as required to check the ebullition and allay the froth which rises to the surface. It must be continually stirred with a wooden spatula, and great care is necessary to prevent its taking fire.

The turpentine is added after the varnish is nearly cool, and it is stirred well in. The varnish must be put in demijohns or close cans, and kept tightly corked.

Grease for Carriage Wheels.

Hog's lard, softened, (if fresh,) by working it.

If this cannot be procured, *tallow* or other grease may be used; if hard, it should be melted with fish oil.

About 1 lb. of grease is required for four wheels.

CHAPTER FOURTEENTH.

MECHANICAL MANŒUVRES.

FIELD ARTILLERY.

The manœuvres may be performed by the men attached to the piece, and require no other implements than those belonging to the piece.

Begin, in all cases, by unlimbering, and taking off the implements attached to the carriage.

To change a Wheel.

Tighten the cap-squares; raise the elevating screw to its whole height; ease the carriage by means of two handspikes, one in the bore of the piece, and the other crossed under the first; support the carriage whilst the wheel is changed. For the 12-pounder carriage, dig a hole 6 in. deep under the wheel that is to remain, in order to prevent it from sliding.

To dismount a Piece.

Take off the cap-squares; run up the elevating screw to its whole height; raise the trail; stand the piece upon its muzzle on the ground, and withdraw the carriage.

To mount a Piece.

Put a handspike under the piece a little in rear of the rimbases, and another under the cascable; place 2 men at the first handspike, 4 at the second, and 2 at the handles, or, (if the piece has no handles,) 4 at each handspike, and raise the piece upon its muzzle; bring up the carriage, raise the trail, and put the piece in its place; put on the cap-squares, and lower the trail, relieving the weight of the piece by raising the muzzle.

In this manœuvre and the preceding, it may be necessary, with the 12-pdr., to make a hole in the ground for the muzzle.

When a piece is upset, separate it from its carriage and remount it as above.

To transport a Piece by means of the Limber.

Detach the prolonge; place the limber over the piece so that the pintle hook shall be over the handles, (or over the rear of the trunnions,) with the breech towards the pole; raise the pole, and elevate the muzzle of the piece; lash the

piece to the pintle hook, with the prolonge, by passing the ring of the prolonge twice through the handles, (or round the piece in rear of the trunnions,) and over the pintle hook; with the loose end of the prolonge, lash the cascable to the fork of the limber.

SIEGE AND GARRISON ARTILLERY.

THE IMPLEMENTS generally used are: 8 *common handspikes*; 1 *lever*, 13 feet long; 1 *block*, 2.5 feet high; 2 *skids*, 15 feet long and 8 in. square; 4 *skids*, 6 feet long, and 8 in. square; 1 *prop*, 3 feet high; 1 *skid*, 8½ in. thick; several short pieces of *skidding*; 4 *chocks* for the wheels, and *several small chocks* or *wedges* for the *rollers*; 1 *double prolonge*, or 2 *single prolonges*, and 2 *drag ropes*; 8 *rollers*, designated by 7 numbers, (there being 2 of No. 7,) of the following dimensions.:

	Diam.	Length.		Diam.	Length.
No. 1.	6 in.	1 ft.	No. 5.*	4½ in.	2 ft.
" 2.	6 "	3½ "	" 6.	4¾ "	3½ "
" 3.	6¾ "	3½ "	" 7.	3 "	3½ "
" 4.	8⅝ "	3½ "			

* One end cut sloping.

ROPES USED IN MECHANICAL MANŒUVRES.

DESIGNATION.	GIRTH.	LENGTH.	NUMBER		WEIGHT.		STRENGTH.
			Of strands.	Of yarns.	Of 1 fathom.	Of whole rope.	
	In.	Feet.			lbs. cz.	lbs. oz.	lbs.
Gin fall - - -	5	120	3	219	6 8½	130	11,200
Drag rope - - -	3½	13	3	102	2 4	6 10	5,378
Double prolonge (with a loop 18 in. long at one end) - - -	3¼	78	3	84	3 1	31	4,760
Single prolonge - - -	3	48	3	74	2 6½	18	4,032
Trace rope - - -	2¼	13	3	45	1 6½	3	2,268
Lashing line - - -	1¾	10	3	24	0 10½	1 1	1,371
Houseline (strong twine)		100	3	9	0 3¼	3 6	251

The prolonges used in the mechanical manœuvres with heavy pieces are those above described. They should be designated by their length, in order to distinguish them from those used for field service.

The above weights of rope are calculated for hemp cordage; the weight of Manilla rope is in proportion to that of hemp rope as 811 to 1000.

The column of *strength* shows the greatest weight the rope will bear, calculated for hemp rope by the rule at page 268. It is double the weight with which ropes should be loaded habitually, although good new rope will bear more than this weight.

The strength of *Manilla rope* is about *one-half* of that of hemp rope.

Knots. For the knots used in mechanical manœuvres, see *Plate 15*.

18 Men are required for most of these mechanical manœuvres. In order to avoid accidents the functions of each man should be designated beforehand. Place the men in two ranks, at 18 inches from each side of the piece or carriage, the two first, opposite the chase ring; the others, at one pace apart. The 1st, 2d, 6th, and 8th pairs have charge of the handspikes; the 3d, chock and lock the wheels, take off and put on the cap squares; the 4th, manage the skids; the 5th, the rollers, and the 7th, the prolonges. Select the strongest men for the handspikes, and the most intelligent for the rollers and skids. Examine carefully the position of the timbers and the knots of the ropes, during the manœuvres; the spare hands assist those at the handspikes. In general, 2 men work at a handspike which is *embarred* or used for heaving, and 4 at a handspike used for lifting.

Preliminary Manœuvres.

Required: 8 handspikes—2 rollers, (Nos. 1 and 5)—1 drag rope—1 8-in. skid—4 chocks for the wheels.

1st.—*To put a roller under the breech.* Raise the breech by bearing down the muzzle, by means of a handspike inserted in the bore and another across the chase; hold it up until the roller No. 1 is placed under the breech.

2nd.—*To put a roller into the trunnion holes.* Raise the piece by means of a handspike inserted in the bore, and three others placed across, one under the first handspike, and the other two under the chase; support it until the roller No. 5 is placed in the trunnion holes.

3d.—*To move the carriage backwards or forwards.* Bear on the spokes of the wheels by means of handspikes resting on or under the cheeks, in front or in rear of the axletree, or on the manœuvring bolts in the barbette carriage.

4th.—*To raise the breech or the muzzle, the piece being either on a carriage or on the ground.* Place two handspikes under each side of the piece, with two men to each, and heave on them.

When the piece is on the ground and so situated that the handspikes cannot take hold: in order to raise the *muzzle*, put a handspike in the bore and pry under it; to raise the *breech*, bring up the carriage; attach a drag rope to the cascable of the piece and to the head of the cheeks; use the carriage as a lever by alternately raising and lowering the trail.

5th.—*To unlimber.* Unhook the lashing chain; raise the trail by means of a handspike placed across under it, assisting the movement by bearing on a handspike inserted in the bore. When the pintle is disengaged, remove the limber, and lower the trail to the ground.

6th.—*To limber up.* Raise the trail as before; back the limber; insert the pintle in the pintle hole, and hook the lashing chain.

To change a Piece from the Trunnion Holes to the Travelling Position.

18 Men—8 handspikes—1 roller, No. 1.

Lock the wheel by one of the lower spokes; take out the elevating screw, and place it in its travelling position; depress the muzzle and place the roller under the piece in rear of the rimbases; raise the muzzle and roll the piece backwards; lower the muzzle again, replace the roller and repeat the operation until the trunnions are in the travelling position; then depress the muzzle, to disengage the roller.

To change a Piece from its Travelling Position to the Trunnion Holes.

Men and implements as before.

Lock the wheel by an upper spoke; raise the breech and put the roller under the piece in rear of the rimbases; lift the muzzle, drawing the piece forwards at the same time; lower the muzzle again, replace the roller, and repeat the operation until the trunnions are in place; then depress the muzzle, to disengage the roller; replace the elevating screw in its box.

To Change a Wheel.

18 Men—8 handspikes—1 lever—1 block—2 chocks.

Chock the wheel which is to remain; raise the carriage by means of the lever and block applied in front of the axletree, and support it until the wheel is changed.

To Mount a Piece on its Carriage.

1st.—*By taking off a wheel.* 18 Men—8 handspikes—1 lever—1 block—1 prop—1 short skid—2 long skids, (15 feet)—3 rollers, Nos. 1, 2, 5—2 chocks for the wheels—several chocks for rollers—1 double prolonge, or 2 single ones.

Put two pieces of skidding under the piece; bring up the carriage, on its limber, in a direction parallel to the piece, the trunnion holes a little forward of the trunnions. Take off the wheel which is towards the piece, lay it on the ground under the arm of the axletree, the large end of the nave uppermost; let the arm of the axletree rest on the short skid placed on the nave. Put the roller, No. 5, in the trunnion holes with the sloped end towards the piece, the

slope uppermost; put the roller, No. 2, on the rear of the cheeks. Place the two long skids parallel to each other, one end of each resting on the cheeks of the carriage, the other on the ground under the piece. Attach the middle of the double prolonge, by an artificer's knot, to the outer end of the nave of the wheel which remains on the carriage; pass the ends of it round the piece, one at the chase, the other in rear of the rimbases, and bring them back towards the wheel; let all the men draw on the ends of the prolonge, except 4, who work with their handspikes on the skids. When the piece is over its place, raise and depress the muzzle successively, to disengage the rollers. Replace the wheel. This manœuvre might be performed without the limber, but it would be attended with some danger.

2nd. *By using the trail as a lever.* Lash a skid across the breech of the piece; bring up the carriage with the wheels touching the skid, and lash them fast to it; raise the trail into a vertical position; pass another skid between the spokes of the wheels, behind the trail, and close to the fellies; haul down the trail, and the breech of the piece will be raised, the muzzle resting on the ground. Take out the skid from between the spokes and replace it as before after having again raised the trail to take a second purchase, which will bring the piece to its place.

To Dismount a Piece.

1st. *By taking off a wheel.* This manœuvre is similar to that of mounting a piece.

2nd. *By the trail.* Place two skids parallel to the stock, one end of each on the axle body, the other on the ground, lashed to the trail; lower the piece on these skids by means of rollers.

To Change a Carriage.

18 Men—8 handspikes—2 skids—3 rollers, Nos. 1, 5, 6—chocks for wheels—1 single prolonge. The spare carriage on its limber; the one with the gun, unlimbered.

Depress the muzzle; put the roller No. 1 under the piece, in rear of the trunnions, between the cheeks, and chock it; run down the elevating screw. Bring up the spare carriage in the rear and place it in the same direction with the other, the wheels touching, and the head of the cheeks of one against the stop bolts of the other; chock the wheels. Place two skids bearing on the axletrees of the two carriages; fasten the prolonge to the cascable by an artificer's knot. Depress the muzzle and replace the roller which is between the cheeks by the roller No. 6, bearing on the skids; place the roller No. 1 on the stock of the new car-

riage, and chock it in front. Raise the muzzle; push the piece at the muzzle and haul on the prolonge, to bring the piece on the two rollers. When the trunnions bear against the chin bolts, put roller No. 5 in the trunnion holes, and let the trunnions down on it by taking a purchase under the chase, to disengage the roller which rests on the skids. Remove the skids and the prolonge; take away the first carriage; withdraw the rollers, by alternately raising and lowering the muzzle.

To Transport a Piece with a Sling Cart.

1st. *With the common sling cart.* 10 Men—1 piece of 5-in. rope—1 double prolonge, or 2 single ones—1 drag rope—4 chocks for wheels—6 handspikes.

The piece being raised from the ground on blocks, bring up the sling cart over the piece, the breech towards the pole; raise the pole vertically, by hand and by means of a prolonge attached to the end of it, and keep it in that position by passing a handspike on each side of it between the spokes of the wheels. Sling the piece with the rope passed under it before and behind the trunnions, and over the bolster; take out the handspikes from between the spokes and lower the pole by means of the prolonge and by hand; lash the breech to it with the drag rope. Bring up the limber.

2nd. *With the screw sling cart.* 4 Men, with lashing ropes. The sling cart being in place, sling the gun with a rope or with chains passing under it and fastened to the hooks of the screw head, or with chains furnished with rings to embrace the trunnions. Raise the piece by turning the handles of the screw nut, and when it is sufficiently high, lash the load to the bolster and pole, so as to relieve the pressure on the screw. The manœuvre is easy but slow, and the machinery must be kept in good order.

To move a Piece by Hand in the Trenches.

40 Men—8 handspikes—1 double prolonge—2 half prolonges, or men's harness.

The piece is on its carriage, without the limber, and may be moved with either the breech or the muzzle foremost. The first method is a little more expeditious, but, in turning sharp angles, it is attended with more danger to the men who support the trail. The second method is preferable. Double the double prolonge, or attach two single prolonges to the axletree; make loops in each part for 5 handspikes, the first under the chase, the others at 3 feet apart; put 4 men at each handspike; 4 behind the trail with handspikes; the rest on the sides, to push the wheels, and if necessary, to drag on them, as described in the

next manœuvre: some of the men at the prolonge leave it to drag on the wheels; in short turnings, those who are at the first handspikes fall back to the others.

To extricate a Piece that is mired.

The number of men in proportion to the difficulty—2 prolonges—hand spikes. Attach a prolonge by one end to one of the lower spokes of each wheel, and bring the other end round to the front, over the tire. The men drag on the prolonges directly, or on the handspikes passed through loops in them.

To lower, from its Chassis, a Barbette Carriage with its Piece mounted.

This carriage can transport its piece with the assistance of the limber of a field piece, from which the ammunition box is removed—18 men are required to remove a 24-pdr.—4 handspikes—1 large block—2 skids—2 short pieces of skidding.

The piece being in battery, lower the elevating screw a little; chock the rollers behind; pass a handspike through the manœuvring loop at the end of the tongue; place two men at each end of this handspike, and two at each end of another passed under the tongue. Raise the chassis, take out the forks and traverse wheels, and lay them on the ground; lower the rear of the chassis on the traversing platform. Put a skid on each side of the chassis, raised on blocks at one end, so that it nearly touches the wheel. Roll the carriage back till the wheels rest upon this skid and the muzzle clears the parapet about three or four feet; put a handspike in the bore, another across the top of the chase, a third through the manœuvring staples, and a fourth under the lunette plate; place two men at the first handspike, and four at each of the three others; raise the trail of the carriage, and place a block under the rear transom. Back up the limber and insert the pintle hook into the lunette. Lighten up the trail, to remove the block; key the pintle hook, and lower the elevating screw. All the men working at the wheels of the carriage and limber, and at the pole, lower the piece gently from the platform. Horses may then be attached to the limber, if necessary.

To raise on its Chassis a Barbette Carriage with its Piece mounted.

The same number of men and the same implements as in the preceding manœuvre. The chassis having been lowered as in the first part of the preceding manœuvre, bring the carriage up to the rear of the platform and place opposite to each wheel a plank resting on two blocks, making a gentle slope to roll the

carriage up on the traversing platform—place skids as before on each side of the chassis—move the carriage forward until the rollers nearly rest upon the rails—run up the elevating screw—lighten up the trail, to disengage the pintle hook—remove the limber, and lower the lunette plate on a block placed upon the tongue—raise the trail again, to remove the block—lower the trail transom upon the tongue—run the carriage up to battery—replace the traverse wheels in the same manner as directed for taking them out, in the preceding manœuvre.

In situations where it may be required, the carriage can be used without its chassis; in this manner it may be applied to the embrasures of field works, by placing it in battery on a common platform for a siege piece and resting the trail on a skid attached to the front hurter by a pintle. The rear of this skid may rest on a block so as to give it the same inclination as the tongue of the chassis.

To place a Casemate Carriage in Battery and mount its Gun.

14 to 16 Men required. The gun is brought to the casemate with the sling cart, and carried through the galleries on a two-wheeled truck. (*Devil cart.*)

The carriage for the embrasure farthest from the door of entrance is to be placed first, and its gun mounted before the next carriage is placed. The tongue of the chassis is inserted into the tongue hole, and the pintle in its hole, through the end of the tongue.

The top carriage is lifted by hand and placed on the chassis, which is traversed on one side, and the gun is laid near the middle of the casemate on blocks, the muzzle towards the embrasure. The casemate gin (legs 14 feet long) is placed over the carriage and gun; the legs and the roller over the gun, the pry-pole over the chassis. The gin is equipped and the gun slung in the usual manner. When the gun is raised sufficiently high, the chassis is traversed under it, and the upper carriage so placed that the trunnion holes come exactly under the trunnions of the gun, which is then lowered carefully to its place. Unslung the gun and remove the gin.

MANŒUVRES OF THE SIEGE AND GARRISON GIN.

10 Men, including a non-commissioned officer as director—5 handspikes—1 gin fall—2 lines—a number of blocks, single or double, according to the manner in which the gin is to be equipped.

To put the Gin together.

Lay the legs on the ground, the outer sides uppermost, the bevels towards each other; place the windlass; connect the heads of the cheeks by the assembling bolt; and insert successively the 1st., 2nd., and 3d. cross bars, and key them.

To carry the Gin.

Put six men at the legs, viz: 2 abreast of the windlass, 2 abreast of the second cross bar, and 2 near the head; 2 men, with a handspike, carry the fall coiled up, with the blocks hooked to it; one man carries the prypole, another the remaining handspikes and the lines.

To set up the Gin.

6 Men, placed in the same manner as for carrying the gin, set it up; 2 men place their feet against the bottom of the legs, or their handspikes against the lower cross bar; one sets up the prypole, two paces in front of the head of the gin, facing it. The director assists by putting the end of a handspike into the slit for the tongue of the prypole. When the prypole is in place, the foot of it should be equally distant from the two legs, 12 feet from the lower cross bar; the pullies should be over the middle of the weight to be raised.

To equip the Gin.

The gin equipped with one pulley, can raise a 12-pounder garrison gun; with 2, a 16-pounder; with 3, a 24-pounder; with 5 or 6, the heaviest weights used in the service of the artillery. It is generally proper to use more pulleys than are absolutely necessary, in order to avoid straining the fall.

1st. *To equip the gin with 1 pulley.* Pass one end of the fall over the windlass, and take 3 turns from left to right, the loose end being outside. Put a handspike in one of the mortices of the windlass, or let down the pall, if there is one; overhaul the fall, letting it wrap round the windlass; pass the end through the right hand pulley of the head, and secure it to the sling round the gun by a capstan knot.

2nd. *With 2 pulleys.* Hang a single block on the second cross bar, the point of the hook outwards; proceed as in the first case; pass the end of the fall through the block on the cross bar, and tie it round the head of the gin, the loose end of the rope hanging on the left side and pinched against the leg. Hook the block to the sling round the gun, the point of the hook towards the left side of the gin.

3d. *With 3 pulleys.* Proceed as for two; pass the end of the fall through the left hand pulley at the head of the gin, from the outside; tie it to the sling on the side towards the pry pole, and hook the block to it on the other side, the point inwards.

4th. *With 4 pulleys.* Hang a second block (or a double block) on the second cross bar. Proceed as in the last case; pass the end of the fall into the

second block and fasten it to the head of the gin as in the second case; hook both blocks to the sling, the points of the hooks inwards.

If a double block is used, place the pin perpendicular to the cross bar, the head towards the pry pole; pass the fall the first time through the sheave next the pry pole, the second time through that next the legs; hook the block to the sling, the point towards the left side of the gin.

5th. *With 5 pulleys.* Hang two single blocks, or a double block, on the second cross bar; fasten a third block to the head of the gin, on the left side, by a collar or coil of rope; the point of the hook being outwards, and the head of the pin towards the gin. Proceed as in the last case; pass the end of the fall into the third block, and fasten the end to the sling round the piece, to which the blocks are also to be hooked.

6th. *With 6 pulleys.* Fix a single block to the head of the gin, another on the second cross bar near the right leg, and a double block on the same cross bar near the left leg. Proceed as in the last case; pass the fall through the single block on the cross bar, and secure it to the head of the gin, the loose end of the rope hanging on the left side, and the third block hooked into the knot. Hook the double block and the other single block to the sling.

The man who directs the manœuvres, or the most intelligent man, should be charged with passing the fall through the pulleys at the head of the gin, and with tying the knots, fixing slings, &c. If he is too much exposed by mounting on the third cross bar, the gin must be laid down, the head resting on the gun, and equipped in that position.

To lay the gin down, the men are placed in the same positions as for setting it up. If the gin has a clevis at the top, the fall may be reeved in the blocks, and the upper block then hooked to the clevis.

To Sling a Piece.

A piece without handles may be slung by means of a rope, the two ends of which are tied together and which is passed under the piece, one-half before and the other behind the trunnions.

If this is not convenient, as when the gun lies on the ground, or is to be placed on its carriage, a sling may be made by joining together the ends of a 6-in. hawser a little more than twice the length of the piece, or by passing a strong rope several times (according to the weight) over the piece lengthwise, under the cascable and under a handspike or a block of wood inserted in the muzzle. The two sides of this sling may be brought together by another just behind the trunnions.

To Work the Gin.

Four men put their handspikes alternately, 2 by 2, in the mortices of the windlass; 2 others assist in heaving; 3 overhaul the slack of the rope; the non-commissioned officer or director steadies the piece or the load, by means of a guy or of a handspike in the bore.

To make fast. If the gin has no ratchet wheel and pall, put a handspike across the legs, and let the heaving handspikes in the mortices rest against it; cross the slack round the turns on the windlass, drawing it tight round the last turn, and pass it under the lower cross bar from the inside, tying it in a loop in which the point of a handspike is inserted; during this operation, one man bears with both hands on the turns round the windlass, to prevent the rope from slipping. The men and 4 handspikes are then no longer required.

To shift the rope on the windlass. When the turns on the windlass, commencing at the left, reach the other end, make fast with the handspikes resting as before. Tie a lashing line to the fall with an artificer's knot, 1 foot above the second cross bar; wrap both ends of the line several times round the fall and pass it round the leg, under the cross bar, lashing the fall and the cross bar together. Let the windlass turn so as to bring the weight to bear on the lashing line; then slip the rope to the left end of the windlass. The gin may be worked, if necessary, by less than 10 men. The men at the slack may be saved by equipping the gin without taking the 3 turns on the windlass; pass the fall over the windlass, and bring it round underneath, placing the slack across the windlass, so that the fall may coil over it. By steadying the piece with a rope attached to the pry pole and to one leg, and by equipping the gin with a greater number of blocks, 3 men may work it, 2 holding the handspikes, and the 3d assisting them alternately.

To use the Gin as a Derrick.

12 Men, 2 being for the guys. Additional implements: 1 double prolonge, or 2 single ones—4 strong pickets, 4 or 5 feet long—2 mauls—and sometimes a second fall and a drag rope.

If the derrick is to be established on a parapet, or on earth which is not firm, lay a strong plank across two others, with holes in the first for the points of the feet; ram the earth about them and secure them with pickets.

Lay the gin down, the outer side underneath, and the feet of the legs resting on a skid.

The director steps 5 paces from the head of the gin, in a direction perpendicular to the cross bars, and then 4 paces to the right and left, where he marks

the places for the two first pickets; the two others are placed 30 feet beyond the first, in the direction which the guys will take.

Drive the pickets inclining off from the gin; if necessary, strengthen them by putting a plank or a fascine behind each, and ramming the earth firmly about it.

Equip the gin as it lies; fasten the guys to the head of it with an artificer's knot, if they are formed of one rope; with German knots, if of two. The gin being raised almost vertically, 2 men take a turn of the guys around the first pickets, and the director makes them fast to the second pickets with an artificer's knot. Let down the fall and tackles, and prepare to work the windlass. On a parapet, the feet of the derrick should be 2 feet from the exterior crest; as the guys, by stretching, are apt to give the derrick too great an inclination, place it at first 4 feet from the crest, and after taking a few turns, let the load down again, and move the derrick to its proper place.

If the fall should not be long enough, join another to it by a flat knot, tied at 4 or 5 yards from the end of the second rope, passing a piece of round wood, of the size of a tool handle, through the knot, to prevent its tightening too much. The first fall passes only through the right hand pulley of the head of the derrick and over the windlass; when the knot comes up near the pulley, cease heaving and make fast; coil a drag rope round the head of the gin and tie it to the second fall by 5 or 6 loops, below the knot. Let go the windlass and bring the weight to bear on the drag rope. Undo the knot, and pass the end of the second fall through the pulley; take 3 turns with it round the windlass, and join the first fall to it, to lengthen the slack.

To use the Gin as a Derrick.

Additional implements: 1 double prolong, 12 Men, 2 being for the guys. 2 single ones—4 strong pickets, 4 or 5 feet long—2 mauls—and sometimes a second fall and a drag rope. If the derrick is to be established on a parapet, or on earth which is not firm, lay a strong plank across two others, with holes in the first for the points of the feet; ram the earth about them and secure them with pickets. Lay the gin down, the outer side underneath, and the feet of the legs resting on a solid. The director steps 5 paces from the head of the gin, in a direction perpendicular to the cross bars, and then 4 paces to the right and left, where he marks

CHAPTER FIFTEENTH.

ARTILLERY PRACTICE—PENETRATION OF SHOT.

The 12-pdr. field howitzer and the 8-in. sea-coast howitzer, being newly introduced into our service, it is thought useful to give the results of the first practice with those pieces, although very limited.

Practice with 12-Pdr. Field Howitzer.

Fort Monroe, 1839.

FIRST GRAZE OF SHELLS.

CHARGE.	ELEVATION.				REMARKS.
	0°	1°	1° 30'	3°	
Lbs.	Yds.	Yds.	Yds.	Yds.	
$\frac{3}{4}$	—	—	367	—	For windage of shells, see <i>Chap. 2</i> .
1	214	403	529	866	Dupont's powder, proof range 300 yds.
$1\frac{1}{4}$	233	457	589	868	The ranges are the means of from 5
$1\frac{1}{2}$	—	—	606	—	to 9 rounds each.

The piece was mounted on a field carriage placed on a platform of rough boards laid under the wheels and trail, inclining about $3\frac{1}{2}^{\circ}$. The recoils with charges of 1 lb. and $1\frac{1}{4}$ lb., were about $4\frac{1}{4}$ ft. and $5\frac{3}{4}$ ft. respectively; with $1\frac{1}{2}$ lb., 8 feet. The extreme ranges of the shells, with the charges of 1 lb. and $1\frac{1}{4}$ lb., were from 1200 to 1300 yards.

It was found that the canister of musket balls, arranged for the mountain howitzer, can be fired with effect from the long 12-pdr. howitzer. At 265 yds., with charges of $\frac{3}{4}$ lb. and 1 lb., (elevation 2°), most of the balls penetrated 1-in. boards; first graze, from 100 to 150 yds; extreme range, about 700 yards.

Practice with 8-in. Sea Coast Howitzer.

Fort Monroe, 1839.

CHARGE.	Eleva- tion.	First Graze.	Extreme range.	Recoil.	REMARKS.	
Lbs.		Yds.	Yds.	Ft.		
SHELLS.	2	4° 15'	900	1700	0.66	For windage of shells, see <i>Chap. 2.</i>
	4	0°	450	1657	2.75	
	4	2° 30'	900	1980	2	
	5	1°	770	1720	2.66	
	5	1° 45'	—	1900	3	
	6	0°	570	2000	4	
	6	1° 30'	880		4	
	8	1°	950		6.5	
GRAPE.	8	10°	—	4400	8.5	An oblong shell weighing 58 lbs. with <i>very little</i> windage. Plates broken into small fragments ; rings found from 350 to 550 yds. ; 3 shot stuck in a target at 930 yards.
	4	2°	350			
	4	4°	500			
	5	4°	700			
	6	4°	800			
			mean			

The howitzer was mounted on a 32-pdr. barbette carriage, with the position of the elevating screw changed to suit the length of the piece. See *Chapter 3.*

The experiments from which the above notes were obtained were made chiefly to ascertain the most suitable kind of fuze for the shell for this howitzer ; the conclusion was in favor of a wooden fuze charged with *mealed powder* hard driven ; it was found best to have the fuze of such a length as nearly to touch the bottom of the shell and to bore it across with a $\frac{1}{4}$ -in. gimlet at the proper point, according to the required time of flight.

The shells and stands of grape were attached to sabots, and for charges under 8 lbs. a cartridge block was used, so as to leave no vacancy between the powder and the projectile.

FIRING HOT SHOT.

FURNACES for heating shot are erected at the forts on the sea coast. These furnaces hold 60 or more shot. The shot being placed, and the furnace cold, it requires 1 hour and 15 minutes to heat them to a red heat. After the furnace is once heated, a 24 pdr. shot is brought to a red heat in 25 minutes ; the 32 and 42 require a few minutes longer. Two or three men are required to attend a furnace.

GRATES. In siege batteries, or in other situations where there are no furnaces a *grate* is used for heating shot. This grate consists of 4 bars, 1.75 in. square,

3 feet long, placed diagonally, 4 in. apart, resting on 3 iron stands with legs 1 foot high.

To use the grate: Make an excavation 1 foot deep and 1 foot wide, with no slope at the sides or in rear, open in front. Place the grate in it, on stones or bricks, rising about 4.5 in. above the bottom; make a roof over it with hoops of flat iron, covered with sods and with 18 in. of earth, leaving in the back part a chimney 6 in. square. Put the shot on the grate, leaving about one fourth of the length free, in front; on this part, and under the front of the grate, put the wood, cut into pieces about 14 in. long and 2 in. or 2.5 in. thick. Make use of a thick sod, as a register, to regulate the draught of the chimney, so that no flame shall issue from the front of the furnace. This little furnace, which will contain about fifteen 24-pdr. balls, heats them to a red heat in 1 hour, and will supply 3 guns; it requires the attendance of one man.

IMPLEMENTS. 2 *Pokers*, for stirring the fire, made of $\frac{3}{4}$ in. round iron, 5½ feet long, the end bent at a right angle—2 *Iron forks*, for taking out the shot. Length of the iron part inserted in a handle, 21 in.; diameter 0.75 in.; length of fork 6.4 in.; interior diameter of the circular portion of prongs 4.5 in.; distance between ends of prongs, 2.75 in. The curvature of the forks embraces $\frac{4}{5}$ of the ball. Length of the wooden handle, 6 feet. These forks are immersed alternately in water to cool them—1 *Rasp*, to rub the scales from the balls when they have been overheated—1 *Pair tongs* with circular jaws, for taking up shot—1 *Iron rake*, to remove the cinders, &c. from the ash pit—1 *Trough or tub*—1 *Bucket*—1 *Barrel*—1 *Rammer*, with the head covered by a circular plate of sheet iron, of rather larger diameter than the ball; to remove the clay which may stick to the sides of the bore when clay wads are used—1 *Ladle*, (to each piece,) for carrying the balls, formed of an iron ring the interior of which is beveled to fit the ball, with 2 arms inserted into wooden handles; for small calibres it may be made with 1 handle.

WADS, may be made of good clay, free from sand or gravel, moistened just enough to work well; the wads are cylindrical, 1 calibre long. But it is preferable to use *hay wads* that have been steeped in water for 15 minutes and allowed to drip.

CARTRIDGES for hot shot, are made of cannon cartridge paper or parchment well pasted, to prevent the powder from sifting out; they should be carefully examined before use, to see that there are no holes in them. It is best to use two cartridge bags, one within the other.

MANNER OF LOADING. Elevate the muzzle sufficiently to allow the ball to roll in; ram the cartridge home carefully, and a *dry* hay wad over it; then a

wet hay or clay wad ; prick and prime ; insert the ball, and put a wet hay or clay wad over it ; this second clay wad may be only $\frac{1}{2}$ calibre long. It is a good precaution also to pass a wet sponge into the gun just before putting in the shot. When wet hay wads are used, steam is seen to issue from the vent as soon as the ball gets home ; this is the effect of the heat of the ball upon the water contained in the wad ; no danger can result from it, as the ball may be allowed to cool in the gun without the charge taking fire ; but it is better to fire without much delay, as this steam would injure the powder.

The penetrations of cold and hot shot into wood are equal under the same circumstances. A red hot shot retains sufficient heat to set fire to wood after having struck the water several times. The fire is communicated more rapidly and certainly to the wood when the ball does not penetrate more than 10 or 12 inches, because at a greater depth the communication with the external air is not sufficiently free. It is proper therefore to fire with small charges, $\frac{1}{4}$ to $\frac{1}{8}$ wt. of the shot, according to the distance, in order that the shot may remain in the wood and not penetrate too deep.

Expansion of Shot heated to a white heat.

CALIBRES.	42	32	24	18	12	REMARKS.
	In.	In.	In.	In.	In.	
Expansion.	0.11	0.10	0.08	0.06	0.04	Experiment at Fort Monroe, 1839. Gassendi, Aide Memoire.
	—	—	0.081	0.067	—	

PENETRATION OF SHOT AND SHELLS.

The following tables and notes, (when not otherwise specified,) are extracted from a report of experiments made at Metz in 1834.

The charges, when expressed in fractions, denote the proportion of powder to the nominal weight of the shot ; the calibres are those of the French guns, the exact relation of which to those of the United States ordnance will be found by reference to the table of foreign ordnance in *Chapter 1*.

The French 36 pdr. corresponds nearly with our 42 pdr. ; the 16 pdr., with our 18 pdr ; the 8 pdr., with our 9 pdr. ; and the 6-in., with our 32 pdr. The diameter of the French 8-in. howitzer is 8.782 inches in our measure. The musket is of the same calibre as ours. The wall piece loads at the breech, with a ball that slugs, weighing 2.368 oz.

Penetration of Shot in Masonry.

Rubble work of good quality ; scarp wall built by Vaubau.

Calibres.	Charges.	Distances in yards.								
		27	55	109	219	328	438	656	875	1094
		In.	In.	In.	In.	In.	In.	In.	In.	In.
36	1-3d	26.78	26.39	25.60	23.83	22.25	20.87	17.92	14.96	12.21
	1-2nd	25.60	25.20	24.22	22.45	20.87	19.30	16.25	13.39	10.83
24	1-3d	24.22	23.83	22.84	21.07	19.50	18.12	15.16	12.21	9.85
	1-4th	22.65	22.25	21.46	19.89	18.22	16.74	13.78	11.23	9.06
	1-6th	20.08	19.69	18.90	17.33	15.75	14.38	11.81	9.65	7.88
	1-8th	17.33	16.93	16.15	14.57	13.20	11.81	9.65	7.88	6.50
	1-2nd	22.45	21.86	20.87	19.10	17.53	15.95	12.80	10.05	7.68
16	1-3d	21.07	20.68	19.69	17.92	16.35	14.77	11.81	9.26	7.29
	1-4th	19.50	19.10	18.22	16.74	15.16	13.78	10.83	8.47	6.69
	1-6th	17.13	16.74	16.15	14.57	13.00	11.62	9.06	7.29	5.91
	1-8th	14.96	14.57	13.78	12.21	10.83	9.45	7.48	6.11	5.12
	1-3d	18.90	18.51	17.53	15.95	14.57	13.00	10.05	7.68	6.11
12	1-4th	17.72	17.33	16.54	14.96	13.39	11.81	8.86	6.89	5.51
	1-6th	15.56	15.16	14.38	13.00	11.42	10.05	7.48	6.11	4.93
	1-8th	13.78	13.39	12.60	11.03	9.65	8.27	6.50	5.12	4.33
8	1-3d	15.95	15.56	14.77	13.19	11.62	10.24	7.48	5.51	4.14

By multiplying the numbers expressing the penetrations in this table by 1.25, we have the penetration in masonry of medium quality ; by 1.75, in brick masonry ; by 0.46, in hard calcareous stone (solid.)

According to the experiments, the holes made in masonry such as that referred to in the table, by shot striking it perpendicularly at a short distance, are formed of an exterior, funnel-shaped opening, the mean diameter of which is about 5 times that of the shot, and of an interior part nearly cylindrical. The exterior cone appears to be produced by the reaction of the masonry, some fragments of which are projected backwards, to the distance of 45 or 50 yards. The train of fragments in front of the hole extends about 20 feet. Around the exterior opening, the masonry is loosened to a distance about one-half greater than the diameter of the opening ; say 45 in., by the 24 pounder shot ; 35.5 inches by the 16 pdr. ; 31.5 in., by the 12 pounder. This loosening indicates the proper distance between the first shots from a breaching battery. Nearly all the shot are broken even at the charge of one-fourth, and the fracture is generally in meridional planes, the pole of which is the point which strikes first. On the shot which are not broken, and on the fragments of those which are broken, small cracks or furrows sometimes 0.02 in. deep, are observed, radiating from the same point.

The effect of shells fired horizontally against masonry is very small ; they

are broken at the moment of striking, or if fired with very low charges, so as not to break, they produce a very slight impression.

Penetration in Oak Wood.

		DISTANCES IN YARDS.									
CALIBRES.	CHARGES.	27	55	109	219	328	438	656	875	1094	
		In.	In.	In.	In.	In.	In.	In.	In.	In.	
Guns.	36	1-3d	65.4	64.2	62.2	58.3	54.3	50.8	44.1	37.4	31.5
	24	1-2nd	63.0	61.4	59.1	54.7	50.8	47.3	40.2	33.5	27.6
		1-3d	59.1	57.9	55.9	51.6	47.6	44.1	37.4	30.7	24.8
		1-4th	55.5	54.3	52.3	48.4	44.9	41.3	35.0	28.4	22.8
		1-6th	49.2	48.4	46.5	42.9	39.4	36.2	29.5	24.0	19.3
		1-8th	42.5	41.6	40.2	36.6	32.7	30.3	24.4	19.7	15.8
	16	1-2nd	54.7	53.2	50.8	46.5	42.5	39.0	31.9	25.6	19.7
		1-3d	51.2	50.0	48.0	43.7	40.2	36.6	29.9	23.6	18.5
		1-4th	47.7	46.5	44.5	40.9	37.4	33.9	27.6	21.7	16.9
		1-6th	42.1	41.4	39.8	36.2	32.7	29.5	23.2	17.7	14.2
		1-8th	37.0	36.2	34.3	30.7	27.6	24.4	19.3	15.0	11.8
	12	1-3d	46.1	44.9	42.9	38.6	35.0	31.9	25.6	19.7	14.6
		1-4th	43.3	42.1	40.2	36.6	33.1	29.9	23.6	18.1	13.4
		1-6th	37.8	37.0	35.4	31.9	28.4	25.2	19.3	15.0	11.4
	8	1-8th	33.9	33.1	31.1	27.6	24.4	21.7	16.5	13.0	9.8
		1-3d	39.4	38.2	36.2	32.3	28.7	25.6	19.3	13.8	10.6
Howitzers.	Lbs.										
8-In. Siege.	4.4	28.4	27.6	26.0	22.4	19.3	16.5	13.0	10.6	9.1	
	3.3	23.2	22.4	20.9	18.1	15.8	13.8	11.0	9.5	8.3	
	2.2	16.1	15.4	14.2	12.6	11.4	10.2	8.7	7.9	7.5	
	1.1	39.1	8.7	8.3	8.3	7.5	7.1	6.7	6.3	5.9	
6-In.	3.3	33.1	31.9	30.3	26.8	23.6	20.5	15.0	11.8	9.8	
	2.2	27.6	26.8	25.2	21.7	18.5	15.8	11.4	9.1	7.9	
	1.65	22.8	22.1	20.5	17.3	14.6	12.6	9.8	8.3	7.1	
24-Pdr.	2.2	27.6	26.8	25.2	21.7	18.1	15.0	10.2	7.9	6.3	
	1.1	18.9	18.1	16.5	13.4	11.0	9.5	7.5	6.3	5.1	
12-Pdr. Mountain	0.6	15.0	14.2	12.6	10.2	8.3	7.1	5.9	4.7	3.9	
Leaden Balls.	Grains.										
Musket -	154	3.35	3.15	2.56	1.77	1.06	0.71	0.32	-	-	
Wall piece -	123	3.54	3.35	2.95	2.24	1.77	1.38	0.98	-	-	

The penetrations in other kinds of wood are deduced from those in the above table by multiplying by 1 for beech and ash; by 1.3, for elm; by 1.8, for white pine and birch; by 2 for poplar.

In oak, the fibres are displaced laterally by the passage of the shot and afterwards close up again, so as to leave an opening scarcely sufficient for measuring the depth of penetration. This effect explains the cause of vessels not being always sunk by shot striking below the water line; but the timber is split lon-

gitudinally even by the smallest shot, in a length of 6.5 feet; the splinters are driven to the distance of 42 to 50 feet and the largest timbers are soon destroyed.

In white pine nearly all the fibres struck by the shot are broken, but the effect does not extend much beyond the opening made; this material is therefore preferable to oak for structures which are not intended to be proof against cannon shot.

Penetration in Compact Earth (half sand, half clay).

CALIBRE.	CHARGE.	DISTANCES IN YARDS.								
		27	55	109	219	328	438	656	875	1094
<i>Guns.</i>		In.	In.	In.	In.	In.	In.	In.	In.	In.
36	1-3d	109.1	106.3	102.4	97.3	93.4	89.4	82.3	75.6	69.7
	1-2	108.3	107.2	99.3	91.0	84.3	79.6	72.5	66.2	60.6
	1-3d	100.4	97.7	92.6	85.9	81.1	77.2	70.1	63.8	58.3
24	1-4th	92.6	90.2	86.6	81.5	77.6	74.0	67.3	61.8	57.1
	1-6th	83.5	82.3	79.9	75.6	72.2	68.9	62.6	57.1	52.4
	1-8th	76.4	74.8	72.4	68.9	65.8	63.0	57.5	52.0	47.3
	1-2	94.5	91.0	85.9	77.6	72.2	67.7	61.4	55.9	50.4
	1-3d	86.6	83.5	79.6	73.6	69.3	65.8	59.9	54.4	49.2
16	1-4th	80.7	78.3	75.2	69.7	66.5	63.4	57.9	52.4	47.3
	1-6th	72.9	70.9	68.1	65.0	61.8	59.1	53.6	48.8	44.5
	1-8th	63.0	65.4	63.8	60.6	57.9	55.1	50.4	45.7	41.3
	1-3d	65.0	63.4	59.9	54.7	50.8	48.2	42.9	38.6	35.0
12	1-4th	60.6	59.1	55.9	52.0	48.8	46.1	41.3	37.4	33.9
	1-6th	54.7	53.6	50.8	48.2	45.3	42.9	38.6	35.0	32.3
	1-8th	50.0	48.8	47.3	44.5	41.7	39.8	36.2	33.1	30.7
8	1-3d	56.3	54.7	52.0	46.9	43.3	40.2	35.4	31.9	28.7
<i>Howitzers.</i>	Lbs.									
	4.4	48.4*	47.3*	45.3*	41.7	38.6	35.4	30.3	26.0	23.2
	3.3	42.9*	41.7	40.2	37.0	33.9	31.1	27.2	24.0	21.7
8-In. Siege.	2.2	34.7	33.9	32.3	29.5	27.6	25.6	22.8	20.9	19.3
	1.1	22.8	22.4	21.7	20.9	20.1	19.3	17.7	16.5	15.8
	3.3	52.8*	51.2*	48.8	45.0	41.0	37.4	30.7	25.2	22.1
6-In.	2.2	45.3	44.1	42.5	38.6	35.0	31.9	26.4	22.4	19.7
	1.65	39.8	38.6	37.0	33.5	30.7	28.0	23.6	20.5	18.1
24-Pdr.	2.2	44.5*	42.9*	41.0*	36.6	32.7	29.1	23.2	18.9	16.1
	1.1	33.5	32.3	30.7	27.6	24.8	22.4	18.1	15.4	13.4
Mountain 12-pdr	0.6	27.2	26.4	24.8	21.7	19.3	17.3	14.6	12.2	10.2
<i>Leadens Balls.</i>	Grains.									
Musket.	154	9.85	9.45	8.66	5.91	4.33	3.15	1.58	-	-
Wall piece.	123	11.81	11.03	9.45	7.48	5.91	4.73	3.15	-	-

* With these charges and at these distances, the shells were often broken.

The penetrations in other kinds of earth are found by multiplying the above by 0.63, for sand mixed with gravel.

“ 0.87, for earth mixed with sand and gravel, and weighing twice as much as water.

“ 1.09, for compact mould and fresh earth mixed with sand, or half clay.

by 1.44, for wet potter's clay.

“ 1.50, for light earth, settled.

“ 1.90, for do. fresh.

In general, sand, sandy earth mixed with gravel or small stones, chalk and tufa, resist shot better than the productive earths, or clay, or earth that retains water.

Penetration of Shells.

Elevation.	Distances.	In compact earth.			In oak wood.			In masonry.		
		8-in.	10-in.	12-in.	8-in.	10-in.	12-in.	8-in.	10-in.	12-in.
	Yds.	In.	In.	In.	In.	In.	In.	In.	In.	In.
30°	{ 656	7.88	17.72	19.69	3.94	7.88	8.66	1.97	3.54	3.94
	{ 1312	9.85	25.60	27.57	4.73	11.81	13.78	2.36	4.73	5.12
45°	{ 656	11.81	19.69	21.66	5.91	9.85	10.63	3.15	3.94	4.33
	{ 1312	15.75	27.57	29.54	7.88	13.78	15.75	3.94	5.51	5.91
60°	{ 656	19.69	29.54	31.50	8.66	13.00	14.57	4.33	5.91	6.30
	{ 1312	21.66	31.50	33.47	9.85	13.78	15.75	4.73	6.30	6.69
Falling with maximum velocity -		23.63	33.47	35.44	9.85	13.78	15.75	4.73	6.69	7.09

The penetrations in other kinds of earth, wood, and stone, may be obtained by using the co-efficients given for the other tables.

Penetration in Fascines, Wool, &c.

At the distance of 24 yards, a musket ball penetrates 20 in. into a gabion stuffed with sap fagots; the ball from a wall piece, 23.63 in. The resistance of fascines decreases very rapidly by the twigs being broken or separated by the balls.

A *rolling gabion*, stuffed with fascines, is proof against the ball of a wall piece at 15 yards; at the distance of 200 yards, and even more, it is pierced through by cannon balls of the smallest calibre.

The penetration of balls in wool is more than double of that in compact earth, even when the wool is contained in close, well quilted mattresses, pressed between hurdles. At 40 yards, a musket ball penetrates more than 40 inches into woollen mattresses thus placed together.

Effects of Shot on Cast Iron.

Shot projected with even a small velocity will break pieces of cast iron of very large dimensions. A 24-pdr. ball fired with a charge of 1-12th and moving with a velocity of 883 feet in a second, split, in two shots, to the depth of 40

inches, a block of cast iron 12 inches wide by 40 inches thick. The fragments of the block and of the broken shot are projected with sufficient velocity to produce the most destructive effects.

According to these results, cast iron cannot be advantageously used either for gun carriages, or for revetments of fortifications.

Penetration in Masonry.

Experiments at Fort Monroe Arsenal, in 1839.

CALIBRE.	Charge.	Elevation.	Distance.	Mean penetration.		
				Dressed granite.	Potomac free stone.	Hard brick.
<i>Shot.</i>	Lbs.		Yds.	In.	In.	In.
32-Pdr. Gun - -	8	1°	880	3.5	12.	15.25
<i>Shell.</i>						
8-Inch Seacoast Howitzer.	6	1° 35'	880	1.	4.5	8.5

The solid shot broke against the granite, but not against the freestone or brick.

The shells broke into small fragments against each of the three materials.

The circumstances attending the penetration of the shot and shells corresponded with those above stated in the experiments at Metz. The wall used as a target was built of dressed stone and of the best bricks, laid in hydraulic cement; but being an isolated wall, (10 feet square of each material, and 5 feet thick, with 3 counterforts,) and being battered before the masonry was perfectly set, the effect of the projectiles in *shattering* the masonry around the point struck was greater than indicated by the experiments referred to.

Experiment in New York Harbor in 1814.

Penetration in a target of white oak timber, 5 feet thick.

GUN.	Charge.	Distance.	Penetration.	REMARKS.
	Lbs.	Yards.	Inches.	
32-Pdr. {	11	100	60	Shot wrapped with leather, so as to destroy the windage.
	11	150	54	

PENETRATION OF LEADEN BALLS.

Experiments made at West Point in 1837.

Penetration in Seasoned White Oak.

ARM.	Charge.	Distances in yards.							REMARKS.
		3½	9	50	100	150	200	300	
	Grains.	In.	In.	In.	In.	In.	In.	In.	
Musket - {	134	2.00	1.60	1.43	1.	0.66	0.55	0.00*	* 1 Ball in 10 im-bedded.
	125	1.60	-	-	-	-	-	-	
	90	1.60	-	-	-	-	-	-	
Common Rifle	92	2.10	1.80	1.43	0.94	0.65	0.29	0.00†	† Indentation 0.2 in.
Hall's Rifle -	70	1.12	1.70	0.63	0.53	0.40	0.00‡	-	‡ 2 Balls in 10 im-bedded.

The musket fired at 9 yards distance, with a charge of 134 grains, 1 ball and 3 buckshot, gave for the ball, a penetration of 1.15 in. ; buckshot 0.41 in.

Penetration in a bundle of musket ball cartridge paper (No. 1.)

Musket, with 134 grains, at 13½ yards . - 653 sheets

Common rifle, 92 do. do. - - 500 sheets.

Experiments at Washington Arsenal, in 1839.

Penetration in Seasoned White Oak.

ARM.	Charge.	Distance.	Penetration.		Remarks.
			Grains.	Yards.	
Musket - - -	144	5	3.00		Arms loaded with new musket powder.
Common Rifle - -	100	"	2.05		
Hall's Rifle - -	100	"	2.00		
Hall's Carbine, musket calibre - - -	70	"	0.60		} Charges too great for service.
	80	"	0.80		
	90	"	1.10		
	100	"	1.20		
Pistol - - -	51	"	0.725		

CHAPTER SIXTEENTH.

MISCELLANEOUS INFORMATION.

WEIGHTS AND MEASURES.

Measures of Length.

Inches.	Feet.	Yards.	Rods or Poles.	Furlongs.	Mile.
12	1				
36	3	1			
198	16½	5½	1		
7920	660	220	40	1	
63360	5280	1760	320	8	1

The inch was formerly divided into three parts, called *barley corns*, and also into 12 parts called *lines*, neither of which denominations is now in common use. Scales and measuring rules are generally divided into *inches*, *quarters*, *eighths* and *sixteenths*; or into *inches* and *decimal parts*; the latter of these divisions is used in the Ordnance Department.

For surveying land: 7.92 Inches = 1 link } Gunter's
100 Links = 4 poles, or 22 yards, or 66 feet. } chain.

For map making: Chains are often made of 50 links, each 1 foot in length.

For measuring ropes and soundings: 1 Fathom = 6 feet.

1 Cable's length = 120 fathoms.

For measuring cloth: 1 Nail = 2¼ inches = 1-16th of a yard.

1 Quarter = 4 nails.

1 Yard = 4 quarters.

1 Ell English = 5 quarters.

For measuring the height of horses: 1 Hand = 4 inches.

Geographical measure: 1 Degree of a great circle of the earth = 69.77 miles.

1 Geographical or nautical mile = 1-60th of a degree of the earth = 2025 yards.

1 Nautical league = 3 miles.

A standard measure has been adopted for the United States, copies of which are distributed to various parts of the country, for the purpose of establishing a uniform system. This standard is a brass rod, which, at the temperature of 32° Fahrenheit, is the standard *yard*. For the proportion which it bears to the French *metre*, see below.

Foreign Measures of Length.

BRITISH. The Imperial standard yard of Great Britain, adopted in 1825, is referred to a natural standard, which is the distance between the axis of suspension and the centre of oscillation of a pendulum which shall vibrate seconds in vacuo, in London, at the level of the sea; that distance measured on a brass rod, at the temperature of 62° Fahr., is declared to be 39.1393 *imperial inches*.

FRENCH. *Old system:*

1 Point	=	0.0074	U. S. inches.
1 Line = 12 points	=	0.08884	"
1 Inch = 12 lines	=	1.06604	"
1 Foot = 12 inches	=	12.7925	"
1 Ell = 43 in. 10 lines	=	46.728	" = 1.298 yd.
1 Toise = 6 feet	=	76.755	" = 2.132 "
1 Perch (Paris) = 18 feet.			
1 Perch (royal) = 22 "			
1 League (common,) 25 to a degree	=	2280 toises	= 4861 yds., = 2.76 miles.
1 League (post) = 2000 toises	=	4264 yds.	= 2.42 miles.
1 Fathom (<i>Brasse</i>) = 5 feet French	=	63.963 inches,	or 5½ feet Eng. nearly.
1 Cable length = 100 toises	=	120 fathoms Fr.,	= 106½ fa- thoms Eng.

TABLE, for reducing old French measures to United States measures.

(According to Mr. Hassler's comparison.)

French feet.	U. States inches	French feet or inches.	U. S. feet or inches.	French lines.	U. States inches.	French points.	U. States inches.
1	12.7925	1	1.0660	1	0.0888	1	0.0074
2	25.5850	2	2.1321	2	0.1777	2	0.0148
3	38.3775	3	3.1981	3	0.2665	3	0.0222
4	51.1700	4	4.2642	4	0.3554	4	0.0296
5	63.9625	5	5.3302	5	0.4442	5	0.0370
6	76.7550	6	6.3963	6	0.5330	6	0.0444
7	89.5475	7	7.4623	7	0.6219	7	0.0518
8	102.3400	8	8.5283	8	0.7107	8	0.0592
9	115.1325	9	9.5944	9	0.7995	9	0.0666
10	127.9250	10	10.6604	10	0.8884	10	0.0740
11	140.7175	11	11.7265	11	0.9772	11	0.0814

NEW FRENCH SYSTEM. The basis of the new French system of measures is the measure of a meridian of the earth, a quadrant of which is 10,000,000 *metres*, measured at the temperature of 32° Fahr. The multiples and divisions of it are decimal, viz: 1 metre = 10 decimetres = 100 centimetres = 1000 millimetres = 39.3809171 U. S. inches, or 3.28174 feet.

Road measure. Myriametre = 10,000 metres. Kilometre = 1000 metres. Decametre = 10 metres. Metre = 0.51317 toise.

TABLE FOR REDUCING METRES TO INCHES.

(According to Mr. Hassler's comparisons; 1 metre = 39.3809171 inches.)

Metres.	Inches.	Metres.	Inches.	Metres.	Inches.	Metres.	Inches.
0.001	0.039381	0.026	1.023904	0.051	2.008427	0.076	2.992950
2	0.078762	27	1.063285	52	2.047808	77	3.032331
3	0.118143	28	1.102666	53	2.087189	78	3.071712
4	0.157524	29	1.142047	54	2.126570	79	3.111093
5	0.196905	0.030	1.181428	55	2.165950	0.080	3.150474
6	0.236286	31	1.220809	56	2.205331	81	3.189855
7	0.275666	32	1.260189	57	2.244712	82	3.229236
8	0.315047	33	1.299570	58	2.284093	83	3.268617
9	0.354428	34	1.338951	59	2.323474	84	3.307998
0.010	0.393809	35	1.378332	0.060	2.362855	85	3.347379
11	0.433190	36	1.417713	61	2.402236	86	3.386759
12	0.472571	37	1.457094	62	2.441617	87	3.426140
13	0.511952	38	1.496475	63	2.480998	88	3.465521
14	0.551333	39	1.535856	64	2.520379	89	3.504902
15	0.590714	0.040	1.575237	65	2.559760	0.090	3.544282
16	0.630095	41	1.614618	66	2.599141	91	3.583663
17	0.669476	42	1.653999	67	2.638522	92	3.623044
18	0.708857	43	1.693379	68	2.677903	93	3.662425
19	0.748237	44	1.732760	69	2.717283	94	3.701806
0.020	0.787618	45	1.772141	0.070	2.756664	95	3.741187
21	0.826999	46	1.811522	71	2.796045	96	3.780568
22	0.866380	47	1.850903	72	2.835426	97	3.819949
23	0.905761	48	1.890284	73	2.874807	98	3.859330
24	0.945142	49	1.929665	74	2.914188	99	3.898711
25	0.984523	0.050	1.969046	75	2.953569	0.100	3.938092

AUSTRIAN. 1 Foot = 12.448 U. S. inches = 1.03737 foot.

PRUSSIAN. } 1 Foot = 12.361 " " = 1.0300 "
RHINELAND. }

SWEDISH. 1 Foot = 11.690 " " = 0.974145 "

SPANISH. { 1 Foot = 11.034 " " = 0.9195 "
League, (royal) = 25,000 Spanish feet = 4½ miles } nearly.
Do. (common) = 19,800 " = 3½ "

*Measures of Surface.**Square measure.* 144 Square inches = 1 square foot.

9 Square feet = 1 square yard.

Land measure. 30 $\frac{1}{4}$ Square yards = 1 square perch or pole.

40 Perches = 1 rood.

160 Perches = 4 roods = 1 acre = 10 square chains (Gunter's) = 4840 square yards = 70 yards square, nearly.

640 Acres = 1 square mile.

*French Superficial Measures.**Old system.* 1 Square inch = 1.1364 U. S. square inches.

1 Arpent (Paris) = 100 square perches (Paris) or 900 square toises = 4088 square yards, or 5-6ths of an acre, nearly.

1 Arpent (woodland) = 100 square perches (royal) = 6108 square yards, or 1 acre, 1 rood, 1 perch.

New, or Decimal system. 1 Are = 100 square metres = 119.665 square yds.

1 Decare = 10 ares. 1 Hectare = 100 ares.

*Measures of Solidity.**Cubic or Solid measure.* 1 Cubic foot = 1728 cubic inches.

1 Cubic yard = 46,656 " " = 27 cubic feet.

Measuring stone. In different parts of the United States the *perch* of stone denotes a different quantity, but it is usually 24 $\frac{3}{4}$ cubic feet.*Measuring wood.* 1 Cord is a prism 4 feet square and 8 feet long = 128 cubic feet.*French Solid Measures.*

1 Cubic foot = 2093.470 cubic inches of the United States.

1 Cubic decimetre = 61.074664 " "

1 Stere = 1 cubic metre = 61074.664 cubic in. = 35.375 cubic feet = 1.309 cubic yard.

*Measures of Capacity.**Liquid Measure.*

	Gills.	Pints.	Quarts.	Gallons.
	4	1	"	"
	8	2	1	"
	32	8	4	1

The standard gallon of the United States is the *wine gallon*, which measures 231 cubic inches, and contains, (as determined by Mr. Hassler,) 58372.1754 Troy grains, or 8.3388822 avoirdupois pounds, of distilled water at the maximum density (39° .83 Fahr.) ; the barometer being at 30 inches.

Dry Measure.

Pints.	Quarts.	Gallons.	Pecks.	Bushels.
2	1			
8	4	1		
16	8	2	1	
64	32	8	4	1

The standard bushel of the United States is the *Winchester bushel*, which measures 2150.4 cubic inches, and contains 543391.89 Troy grains, or 77.627413 lbs. avoirdupois, of distilled water, under the circumstances above stated.

Foreign Measures.

The *British Imperial gallon* measures 277.274 cubic inches, containing *ten pounds* avoirdupois of distilled water, weighed in air, at the temperature of 62°, the barometer being at 30 in. The same measure is used for liquids as for dry goods which are not measured by heaped measure ; for the latter, the bushel is to be heaped in the form of a cone not less than 6 inches high, the base being 9½ inches. The old distinctions of wine measure, ale and beer measure, and dry measure are discontinued.

BRITISH MEASURES. *For grain.* 8 Bushels = 1 quarter = 10.269 cubic feet.
5 Quarters = 1 load = 51.347 “

For coal, or heaped measure. 3 Bushels = 1 sack = 4.89 cubic feet, nearly.
12 Sacks = 36 bushels = 1 chaldron = 59 cubic feet, nearly.

Former wine gallon = 231 cubic inches.
Former ale gallon = 282 cubic inches.
Imperial gallon = 277.274 do. (as above.)

FRENCH. 1 Litre = 1 cubic decimetre = 61.074 U. S. cub. inches = 12.057 U. S. quart = 1.761 imperial pint of Great Britain.
1 Boisseau = 13 litres = 793.364 cub. inches = 3.4349 gallons.
1 Pinte = 0.931 litre = 56.817 cub. in. = 0.98397 quart.

SPANISH. 1 Wine arroba = 4.2455 gallons.
1 Fanega, (corn measure) = 1.593 bushel.

Measures of Weight.

Avoirdupois.

Drams.	Ounces.	Pounds.	Quarters.	Cwt.	Ton.
16	1				
256	16	1			
7168	448	28	1		
28672	1792	112	4	1	
573440	35840	2240	80	20	1

The standard avoirdupois pound of the United States, as determined by Mr. Hassler, is the weight of 27.7015 cubic inches of distilled water weighed in air, at the temperature of the maximum density, (39° .83); the barometer being at 30 inches.

Troy.

Grains.	Dwt.	Ounce.	Pound.
24	1		
480	20	1	
5760	240	12	1

The pound, ounce and grain are the same in Apothecaries' and Troy weight; in the former, the ounce is divided into 8 drachms, the drachm into 3 scruples, and the scruple into 20 grains.

7000 Troy grains = 1 lb. Avoirdupois.

175 Troy pounds = 144 lbs. Avoirdupois.

175 Troy ounces = 192 oz. do.

437½ Troy grains = 1 oz. do.

Foreign Weights.

BRITISH. The imperial avoirdupois pound is the weight of 27.7274 cubic inches of distilled water weighed in air, with brass weights, at the temperature of 62° Fahr.; barometer, 30 inches.

1 Troy grain = .003961 cubic inch of distilled water.

1 Troy pound = 22.815689 cubic inches of water.

Horseman's weight. 1 Stone = 14 pounds.

FRENCH. *Old system.*

1 Livre = 16 onces = 1.0780 lb. avoirdupois.

1 Once = 8 gros = 1.0780 oz. do.

1 Gros = 72 grains = 58.9548 grains Troy.

1 Grain - - = 0.8188 do.

New system.

The basis of the system of weights is the weight, in vacuo, of a litre, or a cubic decimetre, of distilled water, at the temperature of 39°.2 Fahr.; $\frac{1}{1000}$ th part of this weight is a *gramme*, the multiples of which are: 1 Decagramme = 10 grammes—1 Hectogramme = 100 grammes—1 Kilogramme = 1000 gram's. The divisions are: 1 Decigramme = $\frac{1}{10}$ th gramme—1 Centigramme = $\frac{1}{100}$ th gramme—1 Milligramme = $\frac{1}{1000}$ th gramme.

1 Quintal = 100 kilogrammes.

1 Millier = 1000 kilogrammes = 1 ton sea weight, (French.)

1 Kilogramme = 2.204737 pounds avoirdupois.

1 Gramme = 15.433159 grains Troy = 0.03528 oz. avoirdupois.

1 Pound avoirdupois = 0.4535685 kilogramme.

1 Pound Troy = 0.3732223 kilogramme.

SPANISH. 1 Pound = 1.0152 pound avoirdupois.**SWEDISH.** 1 Pound = 0.9376 " "**AUSTRIAN.** 1 Pound = 1.2351 " "**PRUSSIAN.** 1 Pound = 1.0333 " "*Measures of Value.*

All calculations of value in the military service of the United States are expressed in *Dollars* and *cents*, although the denominations of *shillings* and *pence* are still in common use as a nominal currency in many of the States.

The standard of gold and silver is 900 parts of pure metal and 100 of alloy, in 1000 parts of coin.

Weight of Dollar, - - 412.5 grains Troy.

" Eagle, - - 258 "

" Cent, - - 168 "

Weight of other coins in proportion to the above.

Relative Mint Value of United States and Foreign Coins.**Dollars.****GREAT BRITAIN.** 1 Guinea = 21 shillings - = 5.117

1 Sovereign, or 1 pound = 20 shillings - = 4.873

		Dollars.
	1 Crown = 5 shillings - - - =	1.218
	1 Shilling = 12 pence - - - =	0.244
	1 Penny - - - - - =	0.023
FRANCE.	5 Francs - - - - - =	0.9353
	1 Franc = 20 sous - - - =	0.187
	1 Sous - - - - - =	0.0093
SPAIN.	1 Doubloon, or 1 ounce - - =	15.556
AUSTRIA.	1 Ducat - - - - - =	2.22
	1 Crown, or rix dollar - - =	0.97
PRUSSIA.	1 Ducat - - - - - =	2.202
	1 Rix dollar - - - - - =	0.694
RUSSIA.	1 Ducat = 10 roubles - - =	7.724
	1 Rouble - - - - - =	0.748
SWEDEN.	1 Ducat - - - - - =	2.19
	1 Rix dollar - - - - - =	1.08

DIMENSIONS OF DRAWING PAPER.

Demy, -	-	1 ft.	7½ in.	×	1 ft.	3½ inches.
Medium,	-	1 "	10 "	×	1 "	6 "
Royal, -	-	2 "	0 "	×	1 "	7 "
Super royal,	-	2 "	3 "	×	1 "	7 "
Imperial,	-	2 "	5 "	×	1 "	9¼ "
Elephant	-	2 "	3¾ "	×	1 "	10¼ "
Columbier,	-	2 "	9¾ "	×	1 "	11 "
Atlas, -	-	2 "	9 "	×	2 "	2 "
Double elephant,	-	3 "	4 "	×	2 "	2 "
Antiquarian,	-	4 "	4 "	×	2 "	7 "

PHYSICAL DATA.

Working Power of Men and Horses.

A foot soldier travels in 1 minute, in common time, 90 steps = 70 yards.

In quick time, 110 " = 86 "

In double quick, 140 " = 109 "

He occupies in the ranks a front of 20 in., and a depth of 13 in., without the knapsack; the interval between the ranks is 13 in. 5 Men can stand in a space of 1 square yard. Average weight of men 150 lbs. each.

A man travels, without a load, on level ground, during 8½ hours a day, at the rate of 3.7 miles an hour, or 31¼ miles a day. He can carry 111 lbs., 11 miles

in a day. A porter going short distances and returning unloaded, carries 135 lbs. 7 miles a day. He can carry in a wheelbarrow 150 lbs., 10 miles a day.

The maximum power of a strong man, exerted for $2\frac{1}{2}$ minutes, may be stated at 18,000 lbs. raised 1 foot in a minute.—*Mr. Field's experiments*, 1838.

A man of ordinary strength exerts a force of 30 lbs. for 10 hours a day, with a velocity of $2\frac{1}{2}$ feet in a second = 4500 lbs. raised 1 foot in a minute = *one-fifth* the work of a horse.

A horse travels the distance of 400 yards, at a walk, in $4\frac{1}{2}$ minutes; at a trot, in 2 minutes; at a gallop, in 1 minute.

He occupies in the ranks a front of 40 in., a depth of 10 feet; in a stall, from $3\frac{1}{2}$ to $4\frac{1}{2}$ feet front; at picket, 3 feet by 9. Average weight of horses, 1000 lbs. each.

A horse carrying a soldier and his equipments, (say 225 lbs.) travels 25 miles in a day (8 hours.)

A pack horse can carry 250 to 300 lbs., 20 miles a day.

A draught horse can draw 1600 lbs., 23 miles a day; weight of carriage included.

Artillery horses should not be made to draw more than 700 lbs. each, the weight of the carriage included.

The ordinary work of a horse for 8 hours a day may be stated at 22,500 lbs. raised 1 foot in a minute.

In a horse mill, the horse moves at the rate of 3 feet in a second. The diameter of the path should not be less than 25 or 30 feet.

A horse power in steam engines, is estimated at 33,000 lbs. raised 1 foot in a minute; but as a horse can exert that force but 6 hours a day, one steam horse power is equivalent to that of 4 horses.

The number of horse-powers, in a single stroke engine, is expressed by $.0000238 d^2 n p l$; d being the diameter of the piston in inches, n the number of strokes in a minute, l the length of stroke in feet, and p the pressure of steam on a square inch, (diminished usually by $\frac{1}{5}$ for friction and inertia.) In a double stroke engine the power is double the above.

Properties of Metals.

Relative Ductility.

Gold—Silver—Platina—Iron—Copper—Zinc—Tin—Lead.

Malleability.

Gold—Silver—Copper—Tin—Platina—Lead—Zinc—Iron.

Tenacity.*Weight required to break a rod 1 in. square.*

	Pounds.		Pounds.
Cast steel - - -	134,000	Gold - - -	30,000
Bar iron (Swedish) - -	72,000	Bronze (gun metal) - -	30,000
Do. (Salisbury, Con.) -	66,000	Copper (cast) - - -	19,000
Do. (Belleville, Pa.) -	58,500	Iron (cast) - - -	19,000
Do. (English) - - -	56,000	Brass - - -	18,000
Platina - - -	56,000	Tin (cast) - - -	4,800
Silver - - -	40,000	Zinc - - -	3,500
Copper (wrought) - - -	34,000	Lead (cast) - - -	1,800

In general, the tenacity of metals is increased by hammering and wire-drawing.

Power of conducting Electricity.

Copper - - -	10,000	Iron - - -	1,580
Gold - - -	9,360	Tin - - -	1,550
Silver - - -	7,360	Lead - - -	830
Zinc - - -	2,850	Mercury - - -	345
Platina - - -	1,880	Potassium - - -	133

The conducting power of rods of the same metal, of equal diameter, is inversely as their lengths; of rods of equal lengths, it is proportional to the mass and not to the surface.

The conducting power is increased by lowering the temperature, and diminished and finally destroyed, by raising the temperature.

The metals are infinitely better conductors than any other substances. Charcoal which has been exposed to a strong heat is one of the best conductors, but greatly inferior in this respect to iron and platina.

Heat.**Thermometers.**

FIXED POINTS.	Fahrenheit.	Reaumer.	Centigrade.
Freezing point of water - -	32°	0°	0°
Boiling do. do. - -	212°	80°	100°

The zero of Wedgewood's pyrometer corresponds with 1077° Fahr., and 1° Wedgewood is equal to 130 Fahr. Hence for converting from one scale to

$$\text{another, } F^{\circ} = \frac{C^{\circ} \times 9}{5} + 32^{\circ} = \frac{R^{\circ} \times 9}{4} + 32^{\circ} = W^{\circ} \times 130 + 1077.$$

Conducting Power of different Substances.

Gold	-	-	-	10,000	Tin	-	-	-	3,039
Platina	-	-	-	9,810	Lead	-	-	-	1,796
Silver	-	-	-	9,730	Marble	-	-	-	236
Copper	-	-	-	8,932	Porcelain	-	-	-	122
Iron	-	-	-	3,743	Brick clay	-	-	-	114
Zinc	-	-	-	3,638					

Capacity for Caloric, or Specific Heat.

Water	-	-	-	10,000	Silver	-	-	-	557
Sulphur	-	-	-	1,880	Tin	-	-	-	515
Glass	-	-	-	1,770	Mercury	-	-	-	330
Iron	-	-	-	1,000	Platina	-	-	-	314
Copper	-	-	-	949	Gold	-	-	-	298
Zinc	-	-	-	927	Lead	-	-	-	293

The capacity for heat increases sensibly with the temperature.

Expansion by Heat.

Linear Expansion of Solids from 32° to 212°.

Zinc	-	-	-	0.00296	Roman cement	-	-	-	0.00144
Lead	-	-	-	0.00285	Marble, Sicilian	-	-	-	0.00141
Tin (refined)	-	-	-	0.00247	Do. Carrara	-	-	-	0.00119
Silver (fine)	-	-	-	0.00215	Sandstone	-	-	-	0.00117
Brass	-	-	-	0.00184	Slate	-	-	-	0.00104
Copper	-	-	-	0.00171	Granite	-	-	-	0.00090
Gold	-	-	-	0.00170	Glass (flint)	-	-	-	0.00082
Steel (tempered)	-	-	-	0.00112	Brick, stock	-	-	-	0.00055
Iron (soft, hammered)	-	-	-	0.00124	Do. fire	-	-	-	0.00049
Do. (cast)	-	-	-	0.00111	Marble, black Galway	-	-	-	0.00045
Steel (not tempered)	-	-	-	0.00108	Oak, dry	-	-	-	0.00006
Platina	-	-	-	0.00086					

The expansion in surface is expressed by numbers *double* of the above, and the expansion in volume by *triple* numbers.

Expansion of Fluids in bulk, from 32° to 212°.

Mercury	-	-	-	0.01808	Sulphuric acid	-	-	-	0.05882
Water, distilled	-	-	-	0.04330	Oil, (olive and linseed)	-	-	-	0.08333
Water, saturated with com-					Spirits turpentine	-	-	-	0.07143
mon salt	-	-	-	0.05000	Gases, all	-	-	-	0.37500
Alcohol	-	-	-	0.11000					

The rate of expansion of solids and liquids increases with the temperature; that of the gases is uniform for all temperatures.

Melting Points of Solids.

Platinum, palladium, rhodium, lime, silex, fine porcelain, can be melted in small quantities by means of strong lenses, or of the hydro-oxygen blowpipe. *Manganese, iron, cobalt, nickel, plaster of Paris, common pottery*, at 150° to 180° of Wedgewood's pyrometer, say $20,000^{\circ}$ to $24,000^{\circ}$ Fahr. *Iron red hot*, (in day light,) 1207 Fahr. = 1° Wedgewood.

		Fahr.	Wedgewood.
Gold	- - -	$5,237^{\circ}$	= 32°
Silver	- - -	$4,717^{\circ}$	= 28°
Copper	- - -	$4,587^{\circ}$	= 27°
Brass	- - -	$3,809^{\circ}$	= 21°
Flint glass	- - -	$2,377^{\circ}$	= 10°
Antimony	- - -	809°	
Zinc	- - -	680°	
Saltpetre	- - -	660°	
Lead	- - -	612°	Experiments of committee of the Franklin Institute.
Bismuth	- - -	506°	
Tin	- - -	442°	
Alloys. { Lead 2, tin 1 (common solder)	- - -	475°	
Lead 1, tin 1	- - -	393°	
Lead 1, tin 2 (soft solder)	- - -	360°	
Lead 1, tin 1, bismuth 1	- - -	272°	
Lead 2, tin 3, bismuth 5	- - -	212°	
Sulphur	- - -	220°	
Bees-wax, bleached	- - -	155°	
Do. common	- - -	149°	
Tallow	- - -	127°	

Freezing Points of Liquids.

Olive oil	- - -	36° Fahr.	Sulphuric acid	- - -	1° Fahr.
Water	- - -	32°	Brandy	- - -	7°
Milk	- - -	30°	Mercury	- - -	-39°
Vinegar	- - -	28°	Nitric acid	- - -	-55°
Spirits of turpentine	- - -	16°			

Boiling Points of Liquids.

Sulphuric ether	- - -	98°	Phosphorus	- - -	554°
Ammonia	- - -	140°	Spirits of turpentine	- - -	560°
Alcohol	- - -	176°	Sulphur	- - -	570°
Water, and essential oils	- - -	212°	Sulphuric acid	- - -	590°
Water, saturated with common salt	- - -	224°	Linseed oil	- - -	600°
Nitric acid	- - -	248°	Mercury	- - -	660°

Freezing Mixtures.

Nitrate of ammonia 1, water 1 ; thermometer falls from 50° to	4°.
Sulph. soda 8, muriatic acid 5	- - - 50° to 0°.
Common salt 1, snow or ice 2	- - - 32° to -4°.
Cryst. chloride of lime 3, snow 2	- - - 32° to -50°.

Heating Power of Different Combustibles.

The *calorific unit* is the quantity of heat required to raise 1° the temperature of a weight of water equal to that of the combustible used.

The following table gives the quantity of water which would be heated from 32° to 212° by an equal weight of several kinds of fuel, supposing no heat to be lost.

Hydrogen	-	-	-	-	-	234
Olive oil	-	-	-	-	-	100
Tallow	-	-	-	-	-	75
Pit coal, coke, or good charcoal	-	-	-	-	-	70
Wood, perfectly dry, (mean)	-	-	-	-	-	35
Wood, common, 1 year after felling ; turf	-	-	-	-	-	26

The heating power of different kinds of wood (taking equal *weights*) does not vary more than in the proportion of 13 to 14, for the extremes.

Nearly six times as much heat is required to evaporate a given quantity of water, as is required to raise its temperature to the boiling point ; dividing the above numbers by 6, we have therefore the quantity of water which each kind of fuel will evaporate.

In even the best apparatus, not more than *half* the heat produced by the combustion of fuel is economised.

Elastic Force of Steam at Different Temperatures.

[From experiments of Committee of Franklin Institute.]

The unit is the atmospheric pressure, or 1 atmosphere 30 inches of mercury.

Temp.	Press.	Temp.	Press.	Temp.	Press.	Temp.	Press.	Temp.	Press.
212	1	275	3	304½	5	326	7	345	9
235	1½	284	3½	310	5½	331	7½	349	9½
250	2	291½	4	315½	6	336	8	352½	10
264	2½	298½	4½	321	6½	340½	8½		

Velocity of Sound.

At the temperature of 33° the mean velocity of sound is 1100 feet in a second. It is increased or diminished *half a foot* for each degree of temperature above or below 33°.

Velocity and Force of the Wind.

VELOCITY.		Pressure on 1 square foot.	Common designations of the force of the winds.
In 1 hour.	In 1 second.		
Miles.	Feet.	Lbs.	
1	1.47	.005	Hardly perceptible.
2	2.93	.020	Just perceptible.
3	4.40	.044	
4	5.87	.079	
5	7.33	.123	Gentle, pleasant wind.
10	14.67	.492	Pleasant, brisk breeze.
15	22.00	1.107	
20	29.34	1.968	
25	36.67	3.075	Very brisk.
30	44.01	4.429	High wind.
35	51.34	6.027	
40	58.68	7.873	
45	66.01	9.963	Very high.
50	73.35	12.300	A storm or tempest.
60	88.02	17.715	A great storm.
80	117.36	31.490	A hurricane.
100	146.70	49.200	A hurricane that tears up trees, carries buildings before it, &c.

Force of Gravity.

Velocity acquired at the end of one second by a body falling in vacuo, at the level of the sea, in the latitude of London, $g = 32.1915$ feet.

Length of a pendulum vibrating seconds at the level of the sea.

Equator	-	-	-	39.0152 inches.
New York, Lat. 41° 22' 54"	-	-	-	39.1013 "
London, Lat. 51° 31'	-	-	-	39.1393 "

For small arcs, the time of vibration is as the square root of the length of the pendulum.

The force of gravity at the latitude of 45° being represented by g , that at any other latitude l will be $g' = g (1 - 0.002588 \cos 2l)$.

If g represents the force of gravity at the height h , and r the radius of the earth, the force of gravity at the level of the sea will be $g' = g (1 + \frac{5h}{4r})$

Measurement of Heights by means of the Barometer.

$$1. X = 60345.51 [1 + .00111111 (T + T' - 64)]$$

$$\times \text{Log.} \left[\frac{H}{H'} \times \frac{1}{1 + .0001 (t - t')} \right] \times (1 + .002695 \cos. 2 L.)$$

Where X is the required difference of height, in feet;

T , the temperature of the air, in degrees of Fahrenheit, }
 t , the temperature of mercury, } at the lower station.
 H , the height of mercury.

T' , the temperature of the air, }
 t' , the temperature of mercury, } at the upper station.
 H' , the height of mercury.

L , the latitude of the place.

2. Neglecting the corrections for the latitude of the place and for the difference between the temperature of the air and that of the mercury in the barometers at the two stations, the difference of height, in feet, may be expressed approximately by $X = 67.0505 (T + T' + 836) \times \text{Log.} \frac{H}{H'}$.

3. Approximate rule :

For a mean temperature of 55° , the difference of height in feet, is,

$$X = 55,000 \times \frac{H - H'}{H + H'}. \text{ Add 1.440th of this result for each degree which}$$

the mean temperature of the air at the two stations exceeds 55° , and deduct as much for each degree below 55° .

The average quantity of water which falls in rain and snow at Philadelphia is 36 inches in a year.

Limits of vegetation, in the Temperate Zone.

The vine ceases to grow at the height of about 2,300 feet above the level of the sea; Indian corn, 2,800; oak, 3,350; walnut, 3,600; ash, 4,800; yellow pine, 6,200; fir, 6,700.

Perpetual Snow. Under the equator, at 15,800 feet above the level of the sea; in latitude 45° , at 8,400; in latitude 65° , at 5,000.

Variation of the Magnetic Needle.

At West Point—April 16th, 1827 - $6^\circ, 44' 30''$ west.

November 16th, 1839 - $7^\circ, 58' 27''$ west.

Dip of the needle: September 5th, 1839 - $73^\circ 26' 30''$

MATHEMATICAL FORMULÆ AND DATA.

Mensuration.

Lines.

CIRCLE. *Ratio of circumference to diameter*, $p = \frac{355}{113} = 3.1415926$.

Length of an arc $= \frac{a p r}{180}$; r being the radius of the circle, and

a the number of degrees in the arc; or, nearly $= \frac{8c' - c}{3}$;

c being the chord of the arc, and c' the chord of half the arc

$$= \sqrt{\frac{1}{4}c^2 + \text{versine}^2}.$$

Length of 1 degree $= 0.0174533$; radius being 1.

Length of 1 minute $= 0.0002909$.

Length of 1 second $= 0.0000048$.

ELLIPSE. *Circumference* $= \frac{1}{2} \frac{99}{100} p \sqrt{\frac{1}{2}(a^2 + b^2)}$, nearly; a and b being the axes.

PARABOLA: *Length of an arc*, commencing at the vertex, $= \sqrt{\left(\frac{4a^2}{3} + \sqrt{b}\right)}$, nearly; a being the abscissa, and b the ordinate.

Surfaces.

Triangle. Half the base $\times$ the height; or half the product of two sides $\times$ the sine of the included angle, $\left(\frac{1}{2}ab \frac{\sin. c}{R}\right)$; or, $\sqrt{s(s-a)(s-b)(s-c)}$;

a, b, c being the sides, and $s = \frac{a+b+c}{2}$.

Parallelogram. The base $\times$ the height.

Trapezoid. Half the sum of the parallel sides $\times$ the height.

Any Quadrilateral. Half the product of the diagonals $\times$ the sine of their angle.

Any irregular plane figure bounded by curves. Divide the figure into any even number of parts by parallel, equidistant ordinates; let a be the sum of the first and last ordinates, b the sum of the even ordinates, c that of the odd ones except the first and last, d the common distance between them; then, area $= \frac{1}{3}d(a + 4b + 2c)$. Five ordinates will generally be found sufficient.

Circle. $p r^2$; or $\text{diam}^2 \times .7854$; or, $\text{circum}^2 \times .07958$.

Circular sector. $\frac{r a}{2}$; a being the length of the arc in linear measure.

Circular segment. The difference between the sector, and the triangle formed by the cord and the radii; or $\frac{r a - r^2 \sin. A}{2}$; or, nearly,

$$= \frac{4}{15} v (c + \frac{4}{3} \sqrt{\frac{1}{4} c^2 + v^2}); c \text{ being the cord and } v \text{ the versed sine.}$$

Ellipse. $a b \times .7854$; a and b being the axes.

Parabola. $\frac{2}{3} a b$; a being the abscissa, and b the double ordinate.

Right prism or cylinder. Curved surface = height $\times$ perimeter of base.

Right pyramid or cone. Half the slant height $\times$ perimeter of base.

Frustum of a right prism or cylinder. The perimeter of the base $\times$ the distance from the centre of gravity of the upper section to the base. If the prism or cylinder is oblique, multiply this product by the sine of the angle of inclination.

Frustum of a right pyramid or cone. The slant height $\times$ half the sum of the perimeters of the two ends.

Sphere. $4 p r^2$; or, diam. $\times$ circum.; or, diam². $\times$ 3.1416.

Spherical zone or segment. $2 p r h$; or, the height of the zone or segment $\times$ the circumference of the sphere.

Circular spindle. $2 p (r c - a \sqrt{r^2 - \frac{1}{4} c^2})$; a being the length of the arc, and c its chord, or the length of the spindle.

Spherical triangle. $p r^2 \frac{s - 180^\circ}{180^\circ}$; s being the sum of the 3 angles.

Any surface of revolution. $2 p r \times l$; or, the length of the generating element $\times$ the circumference described by its centre of gravity.

TABLE OF REGULAR POLYGONS.

No of sides.	Name.	Area.	Radius of circumscribing circle.	Side of inscribed polygon.
3	Triangle.	0.4330127	0.5773503	1.732051
4	Square.	1.0000000	0.7071068	1.414214
5	Pentagon.	1.7204774	0.8506508	1.175570
6	Hexagon.	2.5980762	1.0000000	1.000000
7	Heptagon.	3.6339124	1.1523824	0.867767
8	Octagon.	4.8284271	1.3065628	0.765367
9	Nonagon.	6.1818242	1.4619022	0.684040
10	Decagon.	7.6942088	1.6180340	0.618034
11	Undecagon.	9.3656399	1.7747324	0.563465
12	Dodecagon.	11.1961524	1.9318517	0.517638

The column of *areas*, in the foregoing table, gives the number by which the *square of the side* is to be multiplied, to find the area of the polygon.

The next column gives the multiplier for the *side of a polygon*, to find the radius of the circumscribing circle.

The last column gives the multiplier for the *radius of a circle*, to find the side of the inscribed polygon.

Solids.

Prism or cylinder. Area of base $\times$ the height.

Pyramid or cone. Area of base $\times \frac{1}{3}$ the height.

Frustum of a pyramid or cone. $\frac{1}{3} h (B + b + \sqrt{Bb})$; h being the height, B and b the areas of the two ends; or, for a conic frustum, $\frac{1}{3} h \times .7854 \times \left(\frac{D^3 - d^3}{D - d} \right)$, D and d being the diameters of the two ends.

Frustum of a right triangular prism. The base $\times \frac{1}{3} (H + H' + H'')$.

Frustum of any right prism. The base $\times$ its distance from the centre of gravity of the section.

Cylindrical segment, contained between the base and an oblique plane passing through a diameter of the base. $\frac{2}{3}$ The height $\times$ the area of the great triangular section; or $\frac{1}{3} r h^2$; r being the radius of the base, and h the height.

Sphere. $\frac{4}{3} p r^3$; or, $\text{diam}^3 \times .5236$.

Spherical segment. $\frac{p h}{6} (3 r^2 - h^2)$; r being the radius of the base, and h the height of the segment; $\frac{p}{6} = 0.5236$.

Spherical zone. $\frac{p h}{6} (3 R^2 + 3 r^2 + h^2)$; R, r being the radii of the bases.

Spherical sector. $\frac{1}{3} r \times$ the surface of the segment or zone.

Ellipsoid. $\frac{p a^2 b}{6}$; a being the revolving diameter and b the axis of revolution.

Paraboloid. $\frac{1}{2}$ The area of the base $\times$ the height.

Circular spindle. $p \left(\frac{1}{6} c^3 - 2 s \sqrt{r^2 - \frac{1}{4} c^2} \right)$; s being the area of the revolving segment and c its chord.

Any solid of revolution. $2 p r s$; or, the area of the generating surface $\times$ the circumference described by its centre of gravity.

Any irregular solid, bounded by a curved surface. Use the rule for finding the area of an irregular plane figure, substituting *sections* for *ordinates*.

Cask gauging. 1. — By the preceding rule:

The content of a cask $= \frac{l p}{24} (d^2 + D^2 + 4 M^2)$; l being the length, $d, D,$

the head and bung diameters, and M , a diameter midway between them, all measured in the clear, inside; $\frac{p}{24} = 0.1309$.

The same formula may be thus stated: $\frac{1}{6} l (A + B + C)$; l being the length; A and B , the areas of the head and bung sections; and C , that of the section midway between them.

2. Content, nearly $= \frac{p l}{12} (2 D^2 + d^2)$; or, $l \times$ the area of a circle whose diameter is $\frac{2 D + d}{3}$.

Centres of Gravity.

Lines.

Circular arc. At a distance from the centre $= \frac{r c}{l}$; r being the radius, c the chord, and l the length of the arc.

Areas.

Triangle. On a line drawn from any angle to the middle of the opposite side, at $\frac{2}{3}$ of the distance from the angle to the side.

Trapezoid. On a line a joining the middle points of the two parallel sides, B, b ; distance from $B = \frac{a}{3} \left(\frac{B + 2b}{B + b} \right)$.

Semicircle. Distance from the centre $= \frac{4 r}{3 p}$.

Circular segment. Distance from the centre $= \frac{c^3}{12 A}$; c being the chord of the segment, and A its area.

Circular sector. Distance from the centre $= \frac{2 r c}{3 l}$; c being the chord, and l the length of the arc.

Surface of a right cylinder, cone, or frustum of a cone. The centre of gravity is at the same distance from the base as that of the parallelogram, triangle or trapezoid which is a right section of the same.

Surface of a spherical zone or segment. At the middle of the height.

Solids.

Prism or cylinder. At the middle of the line joining the centres of gravity of the two ends.

Pyramid or cone. Distance from the base $= \frac{1}{4}$ of the line joining the vertex with the centre of gravity of the base.

Frustum of a cone. Distance from the centre of the smaller end
 $= \frac{1}{4} h \times \frac{(R + r)^2 + 2 R^2}{(R + r)^2 - R r}$; or, $\frac{1}{4} h \times \frac{3 R^2 + 2 R r + r^2}{R^2 + R r + r^2}$; h being the
height, R and r the radii of the greater and less ends.

Spherical segment. Distance from the centre $= \frac{p v^2 (r - v)^2}{s}$; v being the
versed sine, and s the solid contents of the segment.

Distance from the vertex $= v \times \frac{8 r - 3 v}{12 r - 4 v}$

Spherical sector. Distance from the centre $= \frac{3}{4} (r - \frac{1}{2} v)$.

Paraboloid. Distance from the vertex $= \frac{2}{3} v$.

Any system of bodies. Distance of the common centre of gravity from a
given plane $= \frac{B D + B' D' + B'' D'' + \&c.}{B + B' + B'' + \&c.}$; B, B', B'' being the masses
or solid contents of the bodies, and D, D', D'' , the distances of their respective
centres of gravity from the given plane.

Arithmetical Progression.

a , the 1st term; d , the common difference; n , the number of terms; l , the
 n^{th} term; s , the sum of n terms.

$$l = a + d (n - 1); s = \frac{n}{2} (a + l)$$

Geometrical Progression.

r , the common ratio; the rest as above.

$$l = a r^{n-1}; s = \frac{l r - a}{r - 1} = a \frac{(r^n - 1)}{r - 1}$$

Plane Trigonometry.

A, B, C , the three angles; a, b, c , the three sides respectively opposite to them;
 R , the tabular radius; S , the area of the triangle, and p half its perimeter $=$
 $\frac{1}{2} (a + b + c)$.

Right angled Triangles: (A being the right angle.)

$$a = \sqrt{b^2 + c^2}; b = c \frac{\text{tang. } B}{R} = a \frac{\sin. B}{R}$$

Oblique angled Triangles :

$$\frac{a}{\sin. A} = \frac{b}{\sin. B} = \frac{c}{\sin. C}$$

$$\text{Tang. } \frac{1}{2} (A - B) = \text{tang. } \frac{1}{2} (A + B) \times \frac{a - b}{a + b}$$

$$c = \sqrt{\left((a - b)^2 + \frac{4ab \sin.^2 \frac{1}{2} C}{R^2} \right)} = \sqrt{\left(a^2 + b^2 - \frac{2ab \cos. C}{R} \right)}$$

$$\cos. \frac{1}{2} A = R \sqrt{\frac{p(p-a)}{bc}}; \sin. \frac{1}{2} A = R \sqrt{\frac{(p-b)(p-c)}{bc}}$$

$$S = \frac{1}{2} \frac{ab \sin. C}{R} = \sqrt{p(p-a)(p-b)(p-c)}$$

General Formulæ.

$$R. \sin. (a \pm b) = \sin. a \cos. b \pm \sin. b \cos. a.$$

$$R. \cos. (a \pm b) = \cos. a \cos. b \mp \sin. a \sin. b.$$

$$R. (\sin. a \pm \sin. b) = 2 \sin. \frac{1}{2} (a \pm b) \cos. \frac{1}{2} (a \mp b).$$

$$R. (\cos. a + \cos. b) = 2 \cos. \frac{1}{2} (a + b) \cos. \frac{1}{2} (a - b).$$

$$R. (\cos. a - \cos. b) = 2 \sin. \frac{1}{2} (a + b) \sin. \frac{1}{2} (a - b).$$

$$\frac{\sin. a + \sin. b}{\sin. a - \sin. b} = \frac{\text{tang. } \frac{1}{2} (a + b) \cos. \frac{1}{2} (a - b)}{R^2}$$

$$\sin. \frac{1}{2} a = \sqrt{\left(\frac{R^2 - R \cos. a}{2} \right)}; \text{tang. } \frac{1}{2} a = R \sqrt{\left(\frac{R - \cos. a}{R + \cos. a} \right)}$$

$$\text{Chord of } A = 2 \sin. \frac{1}{2} A.$$

Table of Natural Sines and Tangents.

Deg.	Min.	Sine.	Tangent.	Deg.	Min.	Sine.	Tangent.
0	15	0043633	0043634	11	45	2036418	2080003
	30	0087265	0087269	12	00	2079117	2125566
	45	0130896	0130907		15	2121777	2171213
1	00	0174524	0174551		30	2164396	2216947
	15	0218149	0218201		45	2206974	2262769
	30	0261769	0261859	13	00	2249511	2308682
	45	0305385	0305528		15	2292004	2354687
2	00	0348995	0349208		30	2334454	2400788
	15	0392598	0392901		45	2376859	2446984
	30	0436194	0436609	14	00	2419219	2493280
	45	0479781	0480334		15	2461533	2539676
3	00	0523360	0524078		30	2503800	2586176
	15	0566928	0567841		45	2546019	2632780
	30	0610485	0611626	15	00	2588190	2679492
	45	0654031	0655435		15	2630312	2726313
4	00	0697565	0699268		30	2672384	2773245
	15	0741085	0743128		45	2714404	2820292
	30	0784591	0787017	16	00	2756374	2867454
	45	0828082	0830936		15	2798290	2914734
5	00	0871557	0874887		30	2840153	2962135
	15	0915016	0918871		45	2881963	3009658
	30	0958458	0962890	17	00	2923717	3057307
	45	1001881	1006947		15	2965416	3105083
6	00	1045285	1051042		30	3007058	3152988
	15	1088669	1095178		45	3048643	3201025
	30	1132032	1139356	18	00	3090170	3249197
	45	1175374	1183578		15	3131638	3297505
7	00	1218693	1227846		30	3173047	3345953
	15	1261990	1272161		45	3214395	3394543
	30	1305262	1316525	19	00	3255682	3443276
	45	1348509	1360940		15	3296906	3492156
8	00	1391731	1405408		30	3338069	3541186
	15	1434926	1449931		45	3379167	3590367
	30	1478094	1494510	20	00	3420201	3639702
	45	1521234	1539147		15	3461171	3689195
9	00	1564345	1583844		30	3502074	3738847
	15	1607426	1628603		45	3542910	3788661
	30	1650476	1673426	21	00	3583679	3838640
	45	1693495	1718314		15	3624380	3888787
10	00	1736482	1763270		30	3665012	3939105
	15	1779435	1808295		45	3705574	3989595
	30	1822355	1853390	22	00	3746066	4040262
	45	1865240	1898559		15	3786485	4091108
11	00	1908090	1943803		30	3826834	4142136
	15	1950903	1989124		45	3867110	4193348
	30	1993679	2034523	23	00	3907311	4244748

Deg.	Sine.	Tangent.	Deg.	Sine.	Tangent.
24	4067366	4452287	58	8480481	16003345
25	4226183	4663077	59	8571673	16642795
26	4383711	4877326	60	8660254	17320508
27	4539905	5095254	61	8746197	18040478
28	4694716	5317094	62	8829476	18807265
29	4848096	5543091	63	8910065	19626105
30	5000000	5773503	64	8987940	20503038
31	5150381	6008606	65	9063078	21445069
32	5299193	6248694	66	9135455	22460368
33	5446390	6494076	67	9205049	23558524
34	5591929	6745085	68	9271839	24750869
35	5735764	7002075	69	9335804	26050891
36	5877853	7265425	70	9396926	27474774
37	6018150	7535541	71	9455186	29042109
38	6156615	7812856	72	9510565	30776835
39	6293204	8097840	73	9563048	32708526
40	6427876	8390996	74	9612617	34874144
41	6560590	8692867	75	9659258	37320508
42	6691306	9004040	76	9702957	40107809
43	6819984	9325151	77	9743701	43314759
44	6946584	9656888	78	9781476	47046301
45	7071068	10000000	79	9816272	51445540
46	7193398	10355303	80	9848078	56712818
47	7313537	10723687	81	9876883	63137515
48	7431448	11106125	82	9902681	71153697
49	7547096	11503684	83	9925462	81443464
50	7660444	11917536	84	9945219	95143645
51	7771460	12348972	85	9961947	114300520
52	7880108	12799416	86	9975641	143006660
53	7986355	13270448	87	9986295	190811370
54	8090170	13763819	88	9993908	286362530
55	8191520	14281480	89	9998477	572899620
56	8290376	14825610	90	10000000	Infinite.
57	8386706	15398650			

AREAS AND CIRCUMFERENCES OF CIRCLES.

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
1.	.785	3.141	7.	38.484	21.99
.125	.994	3.534	.125	39.871	22.38
.25	1.227	3.927	.25	41.282	22.77
.375	1.484	4.319	.375	42.718	23.16
.5	1.767	4.712	.5	44.179	23.56
.625	2.073	5.105	.625	45.663	23.95
.75	2.405	5.498	.75	47.173	24.35
.875	2.761	5.890	.875	48.707	24.74
2.	3.141	6.283	8.	50.265	25.13
.125	3.546	6.675	.125	51.848	25.52
.25	3.976	7.068	.25	53.456	25.92
.375	4.430	7.461	.375	55.088	26.31
.5	4.909	7.854	.5	56.745	26.70
.625	5.411	8.246	.625	58.426	27.09
.75	5.939	8.639	.75	60.132	27.49
.875	6.491	9.032	.875	61.862	27.88
3.	7.068	9.425	9.	63.617	28.27
.125	7.669	9.817	.125	65.396	28.66
.25	8.296	10.21	.25	67.200	29.06
.375	8.946	10.60	.375	69.029	29.45
.5	9.621	10.99	.5	70.882	29.84
.625	10.320	11.38	.625	72.759	30.23
.75	11.045	11.78	.75	74.662	30.63
.875	11.793	12.17	.875	76.588	31.02
4.	12.566	12.56	10.	78.540	31.41
.125	13.364	12.95	.125	80.515	31.80
.25	14.186	13.35	.25	82.516	32.20
.375	15.033	13.74	.375	84.540	32.59
.5	15.904	14.14	.5	86.590	32.99
.625	16.800	14.52	.625	88.664	33.37
.75	17.720	14.92	.75	90.762	33.77
.875	18.665	15.31	.875	92.885	34.16
5.	19.635	15.71	11.	95.033	34.56
.125	20.629	16.10	.125	97.205	34.95
.25	21.647	16.49	.25	99.402	35.34
.375	22.690	16.88	.375	101.62	35.73
.5	23.758	17.28	.5	103.87	36.13
.625	24.850	16.67	.625	106.13	36.52
.75	25.967	18.06	.75	108.43	36.91
.875	27.108	18.45	.875	110.75	37.30
6.	28.274	18.85	12.	113.09	37.70
.125	29.464	19.24	.125	115.46	38.09
.25	30.680	19.63	.25	117.86	38.48
.375	31.919	20.02	.375	120.27	38.87
.5	33.183	20.42	.5	122.71	39.27
.625	34.471	20.81	.625	125.18	39.66
.75	35.785	21.20	.75	127.67	40.05
.875	37.122	21.57	.875	130.19	40.44

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
13.	132.73	40.84	19.	283.53	59.69
.125	135.29	41.23	.125	287.27	60.08
.25	137.89	41.63	.25	291.04	60.47
.375	140.50	42.01	.375	294.83	60.86
.5	143.14	42.41	.5	298.65	61.26
.625	145.80	42.80	.625	302.48	61.65
.75	148.48	43.29	.75	306.35	62.04
.875	151.20	43.58	.875	310.24	62.45
14.	153.94	43.98	20.	314.16	62.83
.125	156.69	44.37	.125	318.09	63.22
.25	159.48	44.77	.25	322.06	63.61
.375	162.29	45.16	.375	326.05	64.01
.5	165.13	45.55	.5	330.06	64.40
.625	167.98	45.94	.625	334.10	64.79
.75	170.87	46.33	.75	338.16	65.19
.875	173.78	46.73	.875	342.25	65.58
15.	176.71	47.12	21.	346.36	65.97
.125	179.67	47.51	.125	350.49	66.36
.25	182.65	47.91	.25	354.65	66.76
.375	185.66	48.30	.375	358.84	67.15
.5	188.69	48.69	.5	363.05	67.54
.625	191.74	49.08	.625	367.28	67.93
.75	194.83	49.48	.75	371.54	68.33
.875	197.93	49.87	.875	375.82	68.72
16.	201.06	50.26	22.	380.13	69.11
.125	204.21	50.65	.125	384.46	69.50
.25	207.39	51.05	.25	388.82	69.90
.375	210.59	51.44	.375	393.20	70.29
.5	213.82	51.84	.5	397.61	70.68
.625	217.07	52.22	.625	402.03	71.07
.75	220.35	52.62	.75	406.49	71.74
.875	223.65	53.01	.875	410.97	71.86
17.	226.98	53.41	23.	415.47	72.25
.125	230.33	53.79	.125	420.00	72.64
.25	233.70	54.19	.25	424.55	73.04
.375	237.10	54.58	.375	429.13	73.43
.5	240.52	54.98	.5	433.74	73.83
.625	243.97	55.37	.625	438.36	74.21
.75	247.45	55.76	.75	443.01	74.61
.875	250.94	56.15	.875	447.69	75.00
18.	254.47	56.55	24.	452.39	75.40
.125	258.01	56.94	.125	457.11	75.79
.25	261.58	57.33	.25	461.86	76.18
.375	265.18	57.72	.375	466.63	76.57
.5	268.80	58.12	.5	471.43	76.97
.625	272.44	58.51	.625	476.25	77.36
.75	276.12	58.90	.75	481.10	77.75
.875	279.81	59.29	.875	485.97	78.14

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
25.	490.87	78.54	31.	754.77	97.39
.125	495.79	78.93	.125	760.86	97.78
.25	500.74	79.32	.25	766.99	98.17
.375	505.71	79.71	.375	773.14	98.56
.5	510.70	80.10	.5	779.31	98.96
.625	515.72	80.50	.625	785.51	99.35
.75	520.77	80.90	.75	791.73	99.74
.875	525.83	81.28	.875	797.97	100.1
26.	530.93	81.68	32.	804.25	100.5
.125	536.04	82.07	.125	810.54	100.9
.25	541.19	82.46	.25	816.86	101.3
.375	546.35	82.85	.375	823.21	101.7
.5	551.54	83.25	.5	829.57	102.1
.625	556.76	83.64	.625	835.97	102.4
.75	562.00	84.04	.75	842.39	102.9
.875	567.26	84.43	.875	848.83	103.2
27.	572.55	84.82	33.	855.30	103.7
.125	577.87	85.21	.125	861.79	104.0
.25	583.21	85.61	.25	868.30	104.5
.375	588.57	86.00	.375	874.84	104.8
.5	593.95	86.39	.5	881.41	105.2
.625	599.37	86.78	.625	888.00	105.6
.75	604.80	87.18	.75	894.62	106.0
.875	610.26	87.57	.875	901.25	106.4
28.	615.75	87.96	34.	907.92	106.8
.125	621.26	88.35	.125	914.61	107.2
.25	626.80	88.75	.25	921.32	107.6
.375	632.35	89.14	.375	928.06	107.9
.5	637.94	89.53	.5	934.82	108.4
.625	643.54	89.92	.625	941.60	108.7
.75	649.18	90.32	.75	948.42	109.2
.875	654.83	90.71	.875	955.25	109.5
29.	660.52	91.11	35.	962.11	109.9
.125	666.22	91.49	.125	968.99	110.3
.25	671.96	91.89	.25	975.91	110.7
.375	677.71	92.28	.375	982.84	111.1
.5	683.49	92.67	.5	989.80	111.5
.625	689.29	93.06	.625	996.78	111.9
.75	695.12	93.46	.75	1003.8	112.3
.875	700.98	93.85	.875	1010.8	112.7
30.	706.86	94.25	36.	1017.9	113.1
.125	712.76	94.64	.125	1024.9	113.4
.25	718.69	95.03	.25	1032.0	113.9
.375	724.64	95.42	.375	1039.1	114.2
.5	730.62	95.82	.5	1046.3	114.6
.625	736.61	96.21	.625	1053.5	115.0
.75	742.64	96.60	.75	1060.7	115.4
.876	748.69	96.99	.875	1067.9	115.8

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
37.	1075.2	116.2	43.	1452.2	135.1
.125	1082.4	116.6	.125	1460.6	135.4
.25	1089.8	117.0	.25	1469.1	135.9
.375	1097.1	117.4	.375	1477.6	136.2
.5	1104.4	117.8	.5	1486.1	136.6
.625	1111.8	118.2	.625	1494.7	137.0
.75	1119.2	118.6	.75	1503.3	137.4
.875	1126.6	118.9	.875	1511.9	137.8
38.	1134.1	119.4	44.	1520.5	138.2
.125	1141.5	119.7	.125	1529.1	138.6
.25	1149.1	120.2	.25	1537.8	139.0
.375	1156.6	120.5	.375	1546.5	139.4
.5	1164.1	120.9	.5	1555.3	139.8
.625	1171.7	121.3	.625	1564.0	140.1
.75	1179.3	121.7	.75	1572.8	140.6
.875	1186.9	122.1	.875	1581.6	140.9
39.	1194.6	122.5	45.	1590.4	141.4
.125	1202.2	122.9	.125	1599.2	141.7
.25	1209.9	123.3	.25	1608.1	142.1
.375	1217.6	123.7	.375	1617.0	142.5
.5	1225.4	124.1	.5	1626.0	142.9
.625	1233.1	124.4	.625	1634.9	143.3
.75	1241.0	124.8	.75	1643.9	143.7
.875	1248.7	125.2	.875	1652.8	144.1
40.	1256.6	125.6	46.	1661.9	144.5
.125	1264.5	126.0	.125	1670.9	144.9
.25	1272.4	126.4	.25	1680.0	145.3
.375	1280.3	126.8	.375	1689.1	145.6
.5	1288.2	127.2	.5	1698.2	146.1
.625	1296.2	127.6	.625	1707.3	146.4
.75	1304.2	128.0	.75	1716.5	146.9
.875	1312.2	128.4	.875	1725.7	147.2
41.	1320.2	128.8	47.	1734.9	147.6
.125	1328.3	129.1	.125	1744.1	148.0
.25	1336.4	129.6	.25	1753.4	148.4
.375	1334.5	129.9	.375	1762.7	148.8
.5	1352.6	130.4	.5	1772.0	149.2
.625	1360.8	130.7	.625	1781.3	149.6
.75	1369.0	131.2	.75	1790.7	150.0
.875	1377.2	131.5	.875	1800.1	150.4
42.	1385.4	131.9	48.	1809.5	150.8
.125	1393.7	132.3	.125	1818.9	151.1
.25	1402.0	132.7	.25	1828.4	151.6
.375	1410.2	133.1	.375	1837.9	151.9
.5	1418.6	133.5	.5	1847.4	152.4
.625	1426.9	133.9	.625	1856.9	152.7
.75	1435.3	134.3	.75	1866.5	153.1
.875	1443.7	134.6	.875	1876.1	153.5

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
49.	1885.7	153.9	55.	2375.8	172.8
.125	1895.3	154.3	.125	2386.6	173.1
.25	1905.8	154.7	.25	2397.5	173.6
.375	1914.7	155.1	.375	2408.3	173.9
.5	1924.4	155.5	.5	2419.2	174.3
.625	1934.1	155.9	.625	2430.1	174.7
.75	1943.9	156.3	.75	2441.0	175.1
.875	1953.6	156.6	.875	2452.0	175.5
50.	1963.5	157.1	56.	2463.0	175.9
.125	1973.3	157.4	.125	2474.0	176.3
.25	1983.2	157.9	.25	2485.0	176.7
.375	1993.0	158.2	.375	2496.1	177.1
.5	2002.9	158.6	.5	2507.2	177.5
.625	2012.8	159.0	.625	2518.2	177.8
.75	2022.8	159.4	.75	2529.4	178.3
.875	2032.8	159.8	.875	2540.5	178.6
51.	2042.8	160.2	57.	2551.7	179.1
.125	2052.8	160.6	.125	2562.9	179.4
.25	2062.9	161.0	.25	2574.2	179.8
.375	2072.9	161.3	.375	2585.4	180.2
.5	2083.1	161.8	.5	2596.7	180.6
.625	2093.2	162.1	.625	2608.0	181.0
.75	2103.3	162.6	.75	2619.3	181.4
.875	2113.5	162.9	.875	2630.7	181.8
52.	2123.7	163.4	58.	2642.1	182.2
.125	2133.9	163.7	.125	2653.4	182.6
.25	2144.2	164.1	.25	2664.9	183.0
.375	2154.4	164.5	.375	2676.3	183.3
.5	2164.7	164.9	.5	2687.8	183.8
.625	2175.0	165.3	.625	2699.3	184.1
.75	2185.4	165.7	.75	2710.8	184.5
.875	2195.7	166.1	.875	2722.4	184.9
53.	2206.2	166.5	59.	2734.0	185.3
.125	2216.6	166.8	.125	2745.5	185.7
.25	2227.0	167.3	.25	2757.2	186.1
.375	2237.5	167.6	.375	2768.8	186.5
.5	2248.0	168.1	.5	2780.5	186.9
.625	2258.5	168.4	.625	2792.2	187.3
.75	2269.0	168.9	.75	2803.9	187.7
.875	2279.6	169.2	.875	2815.6	188.1
54.	2290.2	169.6	60.	2827.4	188.5
.125	2300.8	170.0	.125	2839.2	188.8
.25	2311.5	170.4	.25	2851.0	189.3
.375	2322.1	170.8	.375	2862.8	189.6
.5	2332.8	171.2	.5	2874.7	190.0
.625	2343.5	171.6	.625	2886.6	190.4
.75	2354.3	172.0	.75	2898.5	190.8
.875	2365.0	172.3	.875	2910.5	191.2

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
61.	2922.5	191.6	67.	3525.6	210.5
.125	2934.4	192.0	.125	3538.8	210.8
.25	2946.5	192.4	.25	3552.0	211.3
.375	2958.5	192.8	.375	3565.2	211.6
.5	2970.6	193.2	.5	3578.5	212.0
.625	2982.6	193.6	.625	3591.7	212.4
.75	2994.8	194.0	.75	3605.0	212.8
.875	3006.9	194.3	.875	3618.3	213.2
62.	3019.1	194.8	68.	3631.7	213.6
.125	3031.2	195.1	.125	3645.0	214.0
.25	3043.5	195.5	.25	3658.4	214.4
.375	3055.7	195.9	.375	3671.8	214.8
.5	3068.0	196.3	.5	3685.3	215.2
.625	3080.2	196.7	.625	3698.7	215.5
.75	3092.5	197.1	.75	3712.2	215.9
.875	3104.8	197.5	.875	3725.7	216.3
63.	3117.2	197.9	69.	3739.3	216.7
.125	3129.6	198.3	.125	3752.8	217.1
.25	3142.0	198.7	.25	3766.4	217.5
.375	3154.4	199.0	.375	3780.0	217.9
.5	3166.9	199.5	.5	3793.6	218.3
.625	3179.4	199.8	.625	3807.3	218.7
.75	3191.9	200.3	.75	3821.0	219.1
.875	3204.4	200.6	.875	3834.7	219.5
64.	3217.0	201.0	70.	3848.4	219.9
.125	3229.5	201.4	.125	3862.2	220.3
.25	3242.2	201.8	.25	3876.0	220.7
.375	3254.8	202.2	.375	3889.8	221.0
.5	3267.4	202.6	.5	3903.6	221.5
.625	3280.1	203.0	.625	3917.4	221.8
.75	3292.8	203.4	.75	3931.3	222.2
.875	3305.5	203.8	.875	3945.2	222.6
65.	3318.3	204.2	71.	3959.2	223.0
.125	3331.0	204.5	.125	3973.1	223.4
.25	3343.9	205.0	.25	3987.1	223.8
.375	3356.7	205.3	.375	4001.1	224.2
.5	3369.5	205.8	.5	4015.1	224.6
.625	3382.4	206.1	.625	4029.2	225.0
.75	3395.3	206.5	.75	4043.3	225.4
.875	3408.2	206.9	.875	4067.3	225.8
66.	3421.2	207.3	72.	4071.5	226.2
.125	3434.1	207.7	.125	4085.6	226.5
.25	3447.2	208.1	.25	4099.8	227.0
.375	3460.1	208.5	.375	4114.0	227.3
.5	3473.2	208.9	.5	4128.2	227.7
.625	3486.3	209.3	.625	4142.5	228.1
.75	3499.4	209.7	.75	4156.8	228.5
.875	3512.5	210.0	.875	4171.0	228.9

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
73.	4185.4	229.3	79.	4901.6	248.2
.125	4199.7	229.7	.125	4917.2	248.5
.25	4214.1	230.1	.25	4932.7	249.0
.375	4228.5	230.5	.375	4948.3	249.3
.5	4242.9	230.9	.5	4963.9	249.7
.625	4257.3	231.3	.625	4979.5	250.1
.75	4271.8	231.7	.75	4995.2	250.5
.875	4286.3	232.0	.875	5010.8	250.9
74.	4300.8	232.5	80.	5026.5	251.3
.125	4315.3	232.8	.125	5042.2	251.7
.25	4329.9	233.2	.25	5058.0	252.1
.375	4344.5	233.6	.375	5073.7	252.5
.5	4359.1	234.0	.5	5089.6	252.8
.625	4373.8	234.4	.625	5105.4	253.2
.75	4388.4	234.8	.75	5121.2	253.6
.875	4403.1	235.2	.875	5137.1	254.0
75.	4417.9	235.6	81.	5153.0	254.4
.125	4432.6	236.0	.125	5168.9	254.8
.25	4447.4	236.4	.25	5184.8	255.2
.375	4462.1	236.7	.375	5200.8	255.6
.5	4477.0	237.2	.5	5216.8	256.0
.625	4491.8	237.5	.625	5232.8	256.4
.75	4506.7	238.0	.75	5248.8	256.8
.875	4521.5	238.3	.875	5264.9	257.2
76.	4536.4	238.7	82.	5281.0	257.6
.125	4551.4	239.1	.125	5297.1	258.0
.25	4566.3	239.5	.25	5313.2	258.4
.375	4581.3	239.9	.375	5329.4	258.7
.5	4596.3	240.3	.5	5345.6	259.2
.625	4611.3	240.7	.625	5361.8	259.5
.75	4626.4	241.1	.75	5378.1	259.9
.875	4641.5	241.5	.875	5394.3	260.3
77.	4656.6	241.9	83.	5410.6	260.7
.125	4671.7	242.2	.125	5426.9	261.1
.25	4686.9	242.7	.25	5443.2	261.5
.375	4702.1	243.0	.375	5459.6	261.9
.5	4717.3	243.5	.5	5476.0	262.3
.625	4732.5	243.8	.625	5492.4	262.7
.75	4747.8	244.2	.75	5508.8	263.1
.875	4763.0	244.6	.875	5525.3	263.5
78.	4778.3	245.0	84.	5541.8	263.9
.125	4793.7	245.4	.125	5558.2	264.2
.25	4809.0	245.8	.25	5574.8	264.6
.375	4824.4	246.2	.375	5591.3	265.0
.5	4839.8	246.6	.5	5607.9	265.4
.625	4855.2	247.0	.625	5624.5	265.8
.75	4870.8	247.4	.75	5641.2	266.2
.875	4886.1	247.7	.875	5657.8	266.6

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
85.	5674.5	267.0	91.	6503.9	285.9
.125	5691.2	267.4	.125	6521.7	286.2
.25	5707.9	267.8	.25	6539.6	286.6
.375	5724.6	268.2	.375	6557.6	287.0
.5	5741.4	268.6	.5	6575.5	287.4
.625	5758.2	268.9	.625	6593.5	287.8
.75	5775.0	269.4	.75	6611.5	288.2
.875	5791.9	269.7	.875	6629.5	288.6
86.	5808.8	270.2	92.	6647.6	289.0
.125	5825.7	270.5	.125	6665.7	289.4
.25	5842.6	270.9	.25	6683.8	289.8
.375	5859.5	271.3	.375	6701.9	290.2
.5	5876.5	271.7	.5	6720.1	290.6
.625	5893.5	272.1	.625	6738.2	290.9
.75	5910.6	272.5	.75	6756.4	291.4
.875	5927.6	272.9	.875	6776.4	291.7
87.	5944.7	273.3	93.	6792.9	292.1
.125	5961.7	273.7	.125	6811.1	292.5
.25	5978.9	274.1	.25	6829.5	292.9
.375	5996.0	274.4	.375	6847.8	293.3
.5	6013.2	274.9	.5	6866.1	293.7
.625	6030.4	275.2	.625	6884.5	294.1
.75	6047.6	275.6	.75	6902.9	294.5
.875	6064.8	276.0	.875	6921.3	294.9
88.	6082.1	276.4	94.	6939.8	295.3
.125	6099.4	276.8	.125	6958.2	295.7
.25	6116.7	277.2	.25	6976.7	296.1
.375	6134.0	277.6	.375	6995.2	296.4
.5	6151.4	278.0	.5	7013.8	296.8
.625	6168.8	278.4	.625	7032.3	297.2
.75	6186.2	278.8	.75	7050.9	297.6
.875	6203.6	279.2	.875	7069.5	298.0
89.	6221.1	279.6	95.	7088.2	298.4
.125	6238.6	279.9	.125	7106.9	298.8
.25	6256.1	280.4	.25	7125.6	299.2
.375	6273.6	280.7	.375	7144.3	299.6
.5	6291.2	281.2	.5	7163.0	300.0
.625	6308.8	281.5	.625	7181.8	300.4
.75	6326.4	281.9	.75	7200.6	300.8
.875	6344.0	282.3	.875	7219.4	301.2
90.	6361.7	282.7	96.	7238.2	301.6
.125	6379.4	283.1	.125	7257.1	301.9
.25	6397.1	283.5	.25	7276.0	302.4
.375	6414.8	283.9	.375	7294.9	302.7
.5	6432.6	284.3	.5	7313.8	303.1
.625	6450.4	284.7	.625	7332.8	303.5
.75	6468.2	285.1	.75	7351.7	303.9
.875	6486.0	285.4	.875	7370.7	304.3

AREAS AND CIRCUMFERENCES OF CIRCLES.

Diameter.	Area.	Circum.	Diameter.	Area.	Circum.
97.	7389.8	304.7	.625	7639.4	309.8
.125	7408.8	305.1	.75	7658.8	310.2
.25	7427.9	305.5	.875	7678.2	310.6
.375	7447.0	305.9	99.	7697.7	311.0
.5	7466.2	306.3	.125	7717.1	311.4
.625	7485.3	306.6	.25	7736.6	311.8
.75	7504.5	307.1	.375	7756.1	312.1
.875	7523.7	307.4	.5	7775.6	312.6
98.	7542.9	307.9	.625	7795.2	312.9
.125	7562.2	308.2	.75	7814.7	313.4
.25	7581.5	308.6	.875	7834.3	313.7
.375	7600.8	309.0	100.	7854.0	314.2
.5	7620.1	309.4			

TABLE OF THE AREAS OF CIRCULAR SEGMENTS.

H.	Area.	H.	Area.	H.	Area.	H.	Area.
.01	.001329	.14	.066833	.27	.171089	.40	.293369
.02	.003748	.15	.073874	.28	.180019	.41	.303187
.03	.006865	.16	.081112	.29	.189047	.42	.313041
.04	.010537	.17	.088535	.30	.198168	.43	.322928
.05	.014681	.18	.096134	.31	.207376	.44	.332843
.06	.019239	.19	.103900	.32	.216666	.45	.342782
.07	.024168	.20	.111823	.33	.226033	.46	.352742
.08	.029435	.21	.119897	.34	.235473	.47	.362717
.09	.035011	.22	.128113	.35	.244980	.48	.372704
.10	.040875	.23	.136465	.36	.254550	.49	.382699
.11	.047005	.24	.144944	.37	.264178	.50	.392699
.12	.053385	.25	.153546	.38	.273861	.001	.000042
.13	.059999	.26	.162263	.39	.283592	.002	.000119

Divide the height of the segment by the diameter of the circle, and look for the quotient in the column H, in the above table, opposite to which will be found a number in column AREA, which multiplied by the square of the diameter will give the area of the segment. Should the height of the segment be greater than half the diameter, find by the foregoing rule the area of the remaining segment, and by subtracting this from the area of the whole circle, the area of the greater segment will be found.

No.	Square.	Cube.	Square Root.	Cube Root.
1	1	1	1.0000000	1.000000
2	4	8	1.4142136	1.259921
3	9	27	1.7320508	1.442250
4	16	64	2.0000000	1.587401
5	25	125	2.2360680	1.709976
6	36	216	2.4494897	1.817121
7	49	343	2.6457513	1.912933
8	64	512	2.8284271	2.000000
9	81	729	3.0000000	2.080084
10	100	1000	3.1622777	2.154435
11	121	1331	3.3166248	2.223980
12	144	1728	3.4641016	2.289428
13	169	2197	3.6055513	2.351335
14	196	2744	3.7416574	2.410142
15	225	3375	3.8729833	2.466212
16	256	4096	4.0000000	2.519842
17	289	4913	4.1231056	2.571282
18	324	5832	4.2426407	2.620741
19	361	6859	4.3588989	2.668402
20	400	8000	4.4721360	2.714418
21	441	9261	4.5825757	2.758923
22	484	10648	4.6904158	2.802039
23	529	12167	4.7958315	2.843867
24	576	13824	4.8989795	2.884499
25	625	15625	5.0000000	2.924018
26	676	17576	5.0990195	2.962496
27	729	19683	5.1961524	3.000000
28	784	21952	5.2915026	3.036589
29	841	24389	5.3851648	3.072317
30	900	27000	5.4772256	3.107232
31	961	29791	5.5677644	3.141381
32	1024	32768	5.6568542	3.174802
33	1089	35937	5.7445626	3.207534
34	1156	39304	5.8309519	3.239612
35	1225	42875	5.9160798	3.271066
36	1296	46656	6.0000000	3.301927
37	1369	50653	6.0827605	3.332222
38	1444	54872	6.1644140	3.361975
39	1521	59319	6.2449980	3.391211
40	1600	64000	6.3245553	3.419952
41	1681	68921	6.4031242	3.448217
42	1764	74088	6.4807407	3.476027
43	1849	79507	6.5574385	3.503398
44	1936	85184	6.6332496	3.530348
45	2025	91125	6.7082039	3.556893
46	2116	97336	6.7823300	3.583048
47	2209	103823	6.8556546	3.608826
48	2304	110592	6.9282032	3.634241
49	2401	117649	7.0000000	3.659306
50	2500	125000	7.0710678	3.684031

No.	Square.	Cube.	Square Root.	Cube Root.
51	2601	132651	7.1414284	3.708430
52	2704	140608	7.2111026	3.732511
53	2809	148877	7.2801099	3.756286
54	2916	157464	7.3484692	3.779763
55	3025	166375	7.4161985	3.802953
56	3136	175616	7.4833148	3.825862
57	3249	185193	7.5498344	3.848501
58	3364	195112	7.6157531	3.870877
59	3481	205379	7.6811457	3.892996
60	3600	216000	7.7459667	3.914867
61	3721	226981	7.8102497	3.936497
62	3844	238328	7.8740079	3.957892
63	3969	250047	7.9372539	3.979057
64	4096	262144	8.0000000	4.000000
65	4225	274625	8.0622577	4.020726
66	4356	287496	8.1240384	4.041240
67	4489	300763	8.1853528	4.061548
68	4624	314432	8.2462113	4.081656
69	4761	328509	8.3066239	4.101564
70	4900	343000	8.3666003	4.121285
71	5041	357911	8.4261498	4.140818
72	5184	373248	8.4852814	4.160168
73	5329	389017	8.5440037	4.179339
74	5476	405224	8.6023253	4.198336
75	5625	421875	8.6602540	4.217163
76	5776	438976	8.7177979	4.235824
77	5929	456533	8.7749644	4.254321
78	6084	474552	8.8317609	4.272659
79	6241	493039	8.8881944	4.290841
80	6400	512000	8.9442719	4.308870
81	6561	531441	9.0000000	4.326749
82	6724	551368	9.0553851	4.344481
83	6889	571787	9.1104336	4.362071
84	7056	592704	9.1651514	4.379519
85	7225	614125	9.2195445	4.396830
86	7396	636056	9.2736185	4.414005
87	7569	658503	9.3273791	4.431047
88	7744	681472	9.3808315	4.447960
89	7921	704969	9.4339811	4.464745
90	8100	729000	9.4868330	4.481405
91	8281	753571	9.5393920	4.497942
92	8464	778688	9.5916630	4.514357
93	8649	804357	9.6436508	4.530655
94	8836	830584	9.6953597	4.546836
95	9025	857375	9.7467943	4.562903
96	9216	884736	9.7979590	4.578857
97	9409	912673	9.8488578	4.594701
98	9604	941192	9.8994949	4.610436
99	9801	970299	9.9498744	4.626065
100	10000	1000000	10.0000000	4.641589

Number.	Square.	Cube.	Square Root.	Cube Root.
101	10201	1030301	10.0498756	4.657010
102	10404	1061201	10.0995049	4.672330
103	10609	1092727	10.1488916	4.687548
104	10816	1124864	10.1980390	4.702669
105	11025	1157625	10.2469508	4.717694
106	11236	1191016	10.2956301	4.732624
107	11449	1225043	10.3440804	4.747459
108	11664	1259712	10.3923048	4.762203
109	11881	1295029	10.4403065	4.776856
110	12100	1331000	10.4880885	4.791420
111	12321	1367631	10.5356538	4.805896
112	12544	1404928	10.5830052	4.820284
113	12769	1442897	10.6301458	4.834588
114	12996	1481544	10.6770783	4.848808
115	13225	1520875	10.7238053	4.862944
116	13456	1560896	10.7703296	4.876999
117	13689	1601613	10.8166538	4.890973
118	13924	1643032	10.8627805	4.904868
119	14161	1685159	10.9087121	4.918685
120	14400	1728000	10.9544512	4.932424
121	14641	1771561	11.0000000	4.946088
122	14884	1815848	11.0453610	4.959675
123	15129	1860867	11.0905365	4.973190
124	15376	1906624	11.1355287	4.986631
125	15625	1953125	11.1803399	5.000000
126	15876	2000376	11.2249722	5.013298
127	16129	2048383	11.2694277	5.026526
128	16384	2097152	11.3137085	5.039684
129	16641	2146689	11.3578167	5.052774
130	16900	2197000	11.4017543	5.065797
131	17161	2248091	11.4455231	5.078753
132	17424	2299968	11.4891253	5.091643
133	17689	2352637	11.5325626	5.104469
134	17956	2406104	11.5758369	5.117230
135	18225	2460375	11.6189500	5.129928
136	18496	2515456	11.6619038	5.142563
137	18769	2571353	11.7046999	5.155137
138	19044	2628072	11.7473444	5.167649
139	19321	2685619	11.7898261	5.180101
140	19600	2744000	11.8321596	5.192494
141	19881	2803221	11.8743421	5.204828
142	20164	2863288	11.9163753	5.217103
143	20449	2924207	11.9582607	5.229321
144	20736	2985984	12.0000000	5.241482
145	21025	3048625	12.0415946	5.253588
146	21316	3112136	12.0830460	5.265637
147	21609	3176523	12.1243557	5.277632
148	21904	3241792	12.1655251	5.289572
149	22201	3307949	12.2065556	5.301459
150	22500	3375000	12.2474487	5.313293

Number.	Square.	Cube.	Square Root.	Cube Root.
151	22801	3442951	12.2882057	5.325074
152	23104	3511808	12.3288280	5.336803
153	23409	3581577	12.3693169	5.348481
154	23716	3652264	12.4096736	5.360108
155	24025	3723875	12.4498996	5.371685
156	24336	3796416	12.4899960	5.383213
157	24649	3869893	12.5299641	5.394690
158	24964	3944312	12.5698051	5.406120
159	25281	4019679	12.6095202	5.417501
160	25600	4096000	12.6491106	5.428835
161	25921	4173281	12.6885775	5.440122
162	26244	4251528	12.7279221	5.451362
163	26569	4330747	12.7671453	5.462556
164	26896	4410944	12.8062485	5.473703
165	27225	4492125	12.8452326	5.484806
166	27556	4574296	12.8840987	5.495865
167	27889	4657463	12.9228480	5.506879
168	28224	4741632	12.9614814	5.517848
169	28561	4826809	13.0000000	5.528775
170	28900	4913000	13.0384048	5.539658
171	29241	5000211	13.0766968	5.550499
172	29584	5088448	13.1148770	5.561298
173	29929	5177717	13.1529464	5.572054
174	30276	5268024	13.1909060	5.582770
175	30625	5359375	13.2287566	5.593445
176	30976	5451776	13.2664992	5.604079
177	31329	5545233	13.3041347	5.614673
178	31684	5639752	13.3416641	5.625226
179	32041	5735339	13.3790882	5.635741
180	32400	5832000	13.4164079	5.646216
181	32761	5929741	13.4536240	5.656652
182	33124	6028568	13.4907376	5.667051
183	33489	6128487	13.5277493	5.677411
184	33856	6229504	13.5646600	5.687734
185	34225	6331625	13.6014705	5.698019
186	34596	6434856	13.6381817	5.708267
187	34969	6539203	13.6747943	5.718479
188	35344	6644672	13.7113092	5.728654
189	35721	6751269	13.7477271	5.738794
190	36100	6859000	13.7840488	5.748897
191	36481	6967871	13.8202750	5.758965
192	36864	7077888	13.8564065	5.768998
193	37249	7189057	13.8924440	5.778996
194	37636	7301384	13.9283883	5.788960
195	38025	7414875	13.9642400	5.798890
196	38416	7529536	14.0000000	5.808786
197	38809	7645373	14.0356688	5.818648
198	39204	7762392	14.0712473	5.828476
199	39601	7880599	14.1067360	5.838272
200	40000	8000000	14.1421356	5.848035

Number.	Square.	Cube.	Square Root.	Cube Root.
201	40401	8120601	14.1774469	5.857765
202	40804	8242408	14.2126704	5.867464
203	41209	8365427	14.2478068	5.877130
204	41616	8489664	14.2828569	5.886765
205	42025	8615125	14.3178211	5.896368
206	42436	8741816	14.3527001	5.905941
207	42849	8869743	14.3874946	5.915481
208	43264	8998912	14.4222051	5.924991
209	43681	9123329	14.4568323	5.934473
210	44100	9261000	14.4913767	5.943911
211	44521	9393931	14.5258390	5.953341
212	44944	9528128	14.5602198	5.962731
213	45369	9663597	14.5945195	5.972091
214	45796	9800344	14.6287388	5.981426
215	46225	9938375	14.6628783	5.990727
216	46656	10077696	14.6969385	6.000000
217	47089	10218313	14.7309199	6.009244
218	47524	10360232	14.7648231	6.018463
219	47961	10503459	14.7986486	6.027650
220	48400	10648000	14.8323970	6.036811
221	48841	10793861	14.8660687	6.045943
222	49284	10941048	14.8996644	6.055048
223	49729	11089567	14.9331845	6.064126
224	50176	11239424	14.9666295	6.073177
225	50625	11390625	15.0000000	6.082201
226	51076	11543176	15.0332964	6.091199
227	51529	11697083	15.0665192	6.100170
228	51984	11852352	15.0996689	6.109115
229	52441	12008989	15.1327460	6.118032
230	52900	12167000	15.1657509	6.126925
231	53361	12326391	15.1986842	6.135792
232	53824	12487168	15.2315462	6.144634
233	54289	12649337	15.2643375	6.153449
234	54756	12812904	15.2970585	6.162239
235	55225	12977875	15.3297097	6.171005
236	55696	13144256	15.3622915	6.179747
237	56169	13312053	15.3948043	6.188463
238	56644	13481272	15.4272486	6.197154
239	57121	13651919	15.4596248	6.205821
240	57600	13824000	15.4919334	6.214464
241	58081	13997521	15.5241747	6.223083
242	58564	14172488	15.5563492	6.231678
243	59049	14348907	15.5884573	6.240251
244	59536	14526784	15.6204994	6.248800
245	60025	14706125	15.6524758	6.257324
246	60516	14886936	15.6843871	6.265826
247	61009	15069223	15.7162336	6.274304
248	61504	15252992	15.7480157	6.282760
249	62001	15438249	15.7797338	6.291194
250	62500	15625000	15.8113883	6.299604

Number.	Square.	Cube.	Square Root.	Cube Root.
251	63001	15813251	15.8429795	6.307992
252	63504	16003008	15.8745079	6.316359
253	64009	16194277	15.9059737	6.324704
254	64516	16387064	15.9373775	6.333025
255	65025	16581375	15.9687194	6.341325
256	65536	16777216	16.0000000	6.349602
257	66049	16974593	16.0312195	6.357859
258	66564	17173512	16.0623784	6.366095
259	67081	17373979	16.0934769	6.374310
260	67600	17576000	16.1245155	6.382504
261	68121	17779581	16.1554944	6.390676
262	68644	17984728	16.1864141	6.398827
263	69169	18191447	16.2172747	6.406958
264	69696	18399744	16.2480768	6.415068
265	70225	18609625	16.2788206	6.423157
266	70756	18821096	16.3095064	6.431226
267	71289	19034163	16.3401346	6.439275
268	71824	19248832	16.3707055	6.447305
269	72361	19465109	16.4012195	6.455314
270	72900	19683000	16.4316767	6.463304
271	73441	19902511	16.4620776	6.471274
272	73984	20123648	16.4924225	6.479224
273	74529	20346417	16.5227116	6.487153
274	75076	20570824	16.5529454	6.495064
275	75625	20796875	16.5831240	6.502956
276	76176	21024576	16.6132477	6.510829
277	76729	21253933	16.6433170	6.518684
278	77284	21484952	16.6733320	6.526519
279	77841	21717639	16.7032931	6.534335
280	78400	21952000	16.7332005	6.542132
281	78961	22188041	16.7630546	6.549911
282	79524	22425768	16.7928556	6.557672
283	80089	22665187	16.8226038	6.565415
284	80656	22906304	16.8522995	6.573139
285	81225	23149125	16.8819430	6.580844
286	81796	23393656	16.9115345	6.588531
287	82369	23639903	16.9410743	6.596202
288	82944	23887872	16.9705627	6.603854
289	83521	24137569	17.0000000	6.611488
290	84100	24389000	17.0293864	6.619106
291	84681	24642171	17.0587221	6.626705
292	85264	24897088	17.0880075	6.634287
293	85849	25153757	17.1172428	6.641851
294	86436	25412184	17.1464282	6.649399
295	87025	25672375	17.1755640	6.656930
296	87616	25934336	17.2046505	6.664443
297	88209	26198073	17.2336879	6.671940
298	88804	26463592	17.2626765	6.679419
299	89401	26730899	17.2916165	6.686882
300	90000	27000000	17.3205081	6.694328

Number.	Square.	Cube.	Square Root.	Cube Root.
301	90601	27270901	17.3493516	6.701758
302	91204	27543608	17.3781472	6.709172
303	91809	27818127	17.4068952	6.716569
304	92416	28094464	17.4355958	6.723950
305	93025	28372625	17.4642492	6.731316
306	93636	28652616	17.4928557	6.738665
307	94249	28934443	17.5214155	6.745997
308	94864	29218112	17.5499288	6.753313
309	95481	29503629	17.5783958	6.760614
310	96100	29791000	17.6068169	6.767899
311	96721	30080231	17.6351921	6.775168
312	97344	30371328	17.6635217	6.782422
313	97969	30664297	17.6918060	6.789661
314	98596	30959144	17.7200451	6.796884
315	99225	31255875	17.7482393	6.804091
316	99856	31554496	17.7763888	6.811284
317	100489	31855013	17.8044938	6.818461
318	101124	32157432	17.8325545	6.825624
319	101761	32461759	17.8605711	6.832771
320	102400	32768000	17.8885438	6.839903
321	103041	33076161	17.9164729	6.847021
322	103684	33386248	17.9443584	6.854124
323	104329	33698267	17.9722008	6.861211
324	104976	34012224	18.0000000	6.868284
325	105625	34328125	18.0277564	6.875343
326	106276	34645976	18.0554701	6.882388
327	106929	34965783	18.0831413	6.889419
328	107584	35287552	18.1107703	6.896435
329	108241	35611289	18.1383571	6.903436
330	108900	35937000	18.1659021	6.910423
331	109561	36264691	18.1934054	6.917396
332	110224	36594368	18.2208672	6.924355
333	110889	36926037	18.2482876	6.931300
334	111556	37259704	18.2756669	6.938232
335	112225	37595375	18.3030052	6.945149
336	112896	37933056	18.3303028	6.952053
337	113569	38272753	18.3575598	6.958943
338	114244	38614472	18.3847763	6.965819
339	114921	38958219	18.4119526	6.972682
340	115600	39304000	18.4390889	6.979532
341	116281	39651821	18.4661853	6.986369
342	116964	40001688	18.4932420	6.993191
343	117649	40353607	18.5202592	7.000000
344	118336	40707584	18.5472370	7.006796
345	119025	41063625	18.5741756	7.013579
346	119716	41421736	18.6010752	7.020349
347	120409	41781923	18.6279360	7.027106
348	121104	42144192	18.6547581	7.033850
349	121801	42508549	18.6815417	7.040581
350	122500	42875000	18.7082869	7.047208

Number.	Square.	Cube.	Square Root.	Cube Root.
351	123201	43243551	18.7349940	7.054003
352	123904	43614208	18.7616630	7.060696
353	124609	43986977	18.7882942	7.067376
354	125316	44361864	18.8148877	7.074043
355	126025	44738875	18.8414437	7.080698
356	126736	45118016	18.8679623	7.087341
357	127449	45499293	18.8944436	7.093970
358	128164	45882712	18.9208879	7.100588
359	128881	46268279	18.9472953	7.107193
360	129600	46656000	18.9736660	7.113786
361	130321	47045881	19.0000000	7.120367
362	131044	47437928	19.0262976	7.126935
363	131769	47832147	19.0525589	7.133492
364	132496	48228544	19.0787840	7.140037
365	133225	48627125	19.1049732	7.146569
366	133956	49027896	19.1311265	7.153090
367	134689	49430863	19.1572441	7.159599
368	135424	49836032	19.1833261	7.166095
369	136161	50243409	19.2093727	7.172580
370	136900	50653000	19.2353841	7.179054
371	137641	51064811	19.2613603	7.185516
372	138384	51478848	19.2873015	7.191966
373	139129	51895117	19.3132079	7.198405
374	139876	52313624	19.3390796	7.204832
375	140625	52734375	19.3649167	7.211247
376	141376	53157376	19.3907194	7.217652
377	142129	53582633	19.4164878	7.224045
378	142884	54010152	19.4422221	7.230427
379	143641	54439939	19.4679223	7.236797
380	144400	54872000	19.4935887	7.243156
381	145161	55306341	19.5192213	7.249504
382	145924	55742968	19.5448203	7.255841
383	146689	56181887	19.5703858	7.262167
384	147456	56623104	19.5959179	7.268482
385	148225	57066625	19.6214169	7.274786
386	148996	57512456	19.6468827	7.281079
387	149769	57960603	19.6723156	7.287362
388	150544	58411072	19.6977156	7.293633
389	151321	58863869	19.7230829	7.299893
390	152100	59319000	19.7484177	7.306143
391	152881	59776471	19.7737199	7.312383
392	153664	60236288	19.7989899	7.318611
393	154449	60698457	19.8242276	7.324829
394	155236	61162984	19.8494332	7.331037
395	156025	61629875	19.8746069	7.337234
396	156816	62099136	19.8997487	7.343420
397	157609	62570773	19.9248588	7.349596
398	158404	63044792	19.9499373	7.355762
399	159201	63521199	19.9749844	7.361917
400	160000	64000000	20.0000000	7.368063

Number.	Square.	Cube.	Square Root.	Cube Root.
401	160801	64481201	20.0249344	7.374198
402	161604	64964808	20.0499377	7.380322
403	162409	65450827	20.0748599	7.386437
404	163216	65939264	20.0997512	7.392542
405	164025	66430125	20.1246118	7.398636
406	164836	66923416	20.1494417	7.404720
407	165649	67419143	20.1742410	7.410794
408	166464	67911312	20.1990099	7.416859
409	167281	68417929	20.2237484	7.422914
410	168100	68921000	20.2484567	7.428958
411	168921	69426531	20.2731349	7.434993
412	169744	69934528	20.2977831	7.441018
413	170569	70444997	20.3224014	7.447033
414	171396	70951944	20.3469899	7.453039
415	172225	71473375	20.3715488	7.459036
416	173056	71991296	20.3960781	7.465023
417	173889	72511713	20.4205779	7.470999
418	174724	73034632	20.4450483	7.476966
419	175561	73560059	20.4694895	7.482924
420	176400	74088000	20.4939015	7.488872
421	177241	74618461	20.5182845	7.494810
422	178084	75151448	20.5426386	7.500740
423	178929	75686967	20.5669638	7.506660
424	179776	76225024	20.5912603	7.512571
425	180625	76765625	30.6155281	7.518473
426	181476	77308776	20.6397674	7.524365
427	182329	77854483	20.6639783	7.530248
428	183184	78402752	20.6881609	7.536121
429	184041	78953589	20.7123152	7.541986
430	184900	79507000	20.7364414	7.547841
431	185761	80062991	20.7605395	7.553688
432	186624	80621568	20.7846097	7.559525
433	187489	81182737	20.8086520	7.565353
434	188356	81746504	20.8326667	7.571173
435	189225	82312875	20.8566536	7.576984
436	190096	82881856	20.8806130	7.582786
437	190969	83453453	20.9045450	7.588579
438	191844	84027672	20.9284495	7.594363
439	192721	84604519	20.9523268	7.600138
440	193600	85184000	20.9761770	7.605905
441	194481	85766121	21.0000000	7.611662
442	195364	86350888	21.0237960	7.617411
443	196249	86938307	21.0475652	7.623151
444	197136	87528384	21.0713075	7.628883
445	198025	88121125	21.0950231	7.634606
446	198916	88716536	21.1187121	7.640321
447	199809	89314623	21.1423745	7.646027
448	200704	89915392	21.1660105	7.651725
449	201601	90518849	21.1896201	7.657414
450	202500	91125000	21.2132034	7.663094

Number.	Square.	Cube.	Square Root.	Cube Root.
451	203401	91733851	21.2367606	7.668766
452	204304	92345408	21.2602916	7.674430
453	205209	92959677	21.2837967	7.680085
454	206116	93576664	21.3072758	7.685732
455	207025	94196375	21.3307290	7.691371
456	207936	94818816	21.3541565	7.697002
457	208849	95443993	21.3775583	7.702624
458	209764	96071912	21.4009346	7.708238
459	210681	96702579	21.4242853	7.713844
460	211600	97336000	21.4476106	7.719442
461	212521	97972181	21.4709106	7.725032
462	213444	98611128	21.4941853	7.730614
463	214369	99252847	21.5174348	7.736187
464	215296	99897344	21.5406592	7.741753
465	216225	100544625	21.5638587	7.747310
466	217156	101194696	21.5870331	7.752860
467	218089	101847563	21.6101828	7.758402
468	219024	102503232	21.6333077	7.763936
469	219961	103161709	21.6564078	7.769462
470	220900	103823000	21.6794834	7.774980
471	221841	104487111	21.7025344	7.780490
472	222784	105154048	21.7255610	7.785992
473	223729	105823817	21.7485632	7.791487
474	224676	106496424	21.7715411	7.796974
475	225625	107171875	21.7944947	7.802453
476	226576	107850176	21.8174242	7.807925
477	227529	108531333	21.8403297	7.813389
478	228484	109215352	21.8632111	7.818845
479	229441	109902239	21.8860686	7.824294
480	230400	110592000	21.9089023	7.829735
481	231361	111284641	21.9317122	7.835168
482	232324	111980168	21.9544984	7.840594
483	233289	112678587	21.9772610	7.846013
484	234256	113379904	22.0000000	7.851424
485	235225	114084125	22.0227155	7.856828
486	236196	114791256	22.0454077	7.862224
487	237169	115501303	22.0680765	7.867613
488	238144	116214272	22.0907220	7.872994
489	239121	116930169	22.1133444	7.878368
490	240100	117649000	22.1359436	7.883734
491	241081	118370771	22.1585198	7.889094
492	242064	119095488	22.1810730	7.894446
493	243049	119823157	22.2036033	7.899791
494	244036	120553784	22.2261108	7.905129
495	245025	121287375	22.2485955	7.910460
496	246016	122023936	22.2710575	7.915784
497	247009	122763473	22.2934968	7.921100
498	248004	123505992	22.3159136	7.926408
499	249001	124251499	22.3383079	7.931710
500	250000	125000000	22.3606798	7.937005

Number.	Square.	Cube.	Square Root.	Cube Root.
501	251001	125751501	22.3830293	7.942293
502	252004	126506008	22.4053565	7.947573
503	253009	127263527	22.4276615	7.952847
504	254016	128024064	22.4499443	7.958114
505	255025	128787625	22.4722051	7.963374
506	256036	129554216	22.4944438	7.968627
507	257049	130323843	22.5166605	7.973873
508	258064	131096512	22.5388553	7.979112
509	259081	131872229	22.5610283	7.984344
510	260100	132651000	22.5831796	7.989569
511	261121	133432831	22.6053091	7.994788
512	262144	134217728	22.6274170	8.000000
513	263169	135005697	22.6495033	8.005205
514	264196	135796744	22.6715681	8.010403
515	265225	136590875	22.6936114	8.015595
516	266256	137388096	22.7156334	8.020779
517	267289	138188413	22.7376340	8.025957
518	268324	138991832	22.7596134	8.031129
519	269361	139798359	22.7815715	8.036293
520	270400	140608000	22.8035085	8.041451
521	271441	141420761	22.8254244	8.046603
522	272484	142236648	22.8473193	8.051748
523	273529	143055667	22.8691933	8.056886
524	274576	143877824	22.8910463	8.062018
525	275625	144703125	22.9128785	8.067143
526	276676	145531576	22.9346899	8.072262
527	277729	146363183	22.9564806	8.077374
528	278784	147197952	22.9782506	8.082480
529	279841	148035889	23.0000000	8.087579
530	280900	148877000	23.0217289	8.092672
531	281961	149721291	23.0434372	8.097758
532	283024	150568768	23.0651252	8.102838
533	284089	151419437	23.0867928	8.107912
534	285156	152273304	23.1084400	8.112980
535	286225	153130375	23.1300670	8.118041
536	287296	153990656	23.1516738	8.123096
537	288369	154854153	23.1732605	8.128144
538	289444	155720872	23.1948270	8.133186
539	290521	156590819	23.2163735	8.138223
540	291600	157464000	23.2379001	8.143253
541	292681	158340421	23.2594067	8.148276
542	293764	159220088	23.2808935	8.153293
543	294849	160103007	23.3023604	8.158304
544	295936	160989184	23.3238076	8.163309
545	297025	161878625	23.3452351	8.168308
546	298116	162771336	23.3666429	8.173302
547	299209	163667323	23.3880311	8.178289
548	300304	164566592	23.4093998	8.183269
549	301401	165469149	23.4307490	8.188244
550	302500	166375000	23.4520788	8.193212

Number.	Square.	Cube.	Square Root.	Cube Root.
551	303601	167284151	23.4733892	8.198175
552	304704	168196608	23.4946802	8.203131
553	305809	169112377	23.5159520	8.208082
554	306916	170031464	23.5372046	8.213027
555	308025	170953875	23.5584380	8.217965
556	309136	171879616	23.5796522	8.222898
557	310249	172808693	23.6008474	8.227825
558	311364	173741112	23.6220236	8.232746
559	312481	174676879	23.6431808	8.237661
560	313600	175616000	23.6643191	8.242570
561	314721	176558481	23.6854386	8.247474
562	315844	177504328	23.7065392	8.252371
563	316969	178453547	23.7276210	8.257263
564	318096	179406144	23.7486842	8.262149
565	319225	180362125	23.7697286	8.267029
566	320356	181321496	23.7907545	8.271903
567	321489	182284263	23.8117618	8.276772
568	322624	183250432	23.8327506	8.281635
569	323761	184220009	23.8537209	8.286493
570	324900	185193000	23.8746728	8.291344
571	326041	186169411	23.8956063	8.296190
572	327184	187149248	23.9165215	8.301030
573	328329	188132517	23.9374184	8.305865
574	329476	189119224	23.9582971	8.310694
575	330625	190109375	23.9791576	8.315517
576	331776	191102976	24.0000000	8.320335
577	332929	192100033	24.0208243	8.325147
578	334084	193100552	24.0416306	8.329954
579	335241	194104539	24.0624188	8.334755
580	336400	195112000	24.0831892	8.339551
581	337561	196122941	24.1039416	8.344341
582	338724	197137368	24.1246762	8.349125
583	339889	198155287	24.1453929	8.353904
584	341056	199176704	24.1660919	8.358678
585	342225	200201625	24.1867732	8.363446
586	343396	201230056	24.2074369	8.368209
587	344569	202262003	24.2280829	8.372966
588	345744	203297472	24.2487113	8.377718
589	346921	204336469	24.2693222	8.382465
590	348100	205379000	24.2899156	8.387206
591	349281	206425071	24.3104916	8.391942
592	350464	207474688	24.3310501	8.396673
593	351649	208527857	24.3515913	8.401398
594	352836	209584584	24.3721152	8.406118
595	354025	210644875	24.3926218	8.410832
596	355216	211708736	24.4131112	8.415541
597	356409	212776173	24.4335834	8.420245
598	357604	213847192	24.4540385	8.424944
599	358801	214921799	24.4744765	8.429638
600	360000	216000000	24.4948974	8.434327

Number.	Square.	Cube.	Square Root.	Cube Root.
601	361201	217081801	24.5153013	8.439009
602	362404	218167208	24.5356883	8.443687
603	363609	219256227	24.5560583	8.448360
604	364816	220348864	24.5764115	8.453027
605	366025	221445125	24.5967478	8.457689
606	367236	222545016	24.6170673	8.462347
607	368449	223648543	24.6373700	8.466999
608	369664	224755712	24.6576560	8.471647
609	370881	225866529	24.6779254	8.476289
610	372100	226981000	24.6981781	8.480926
611	373321	228099131	24.7184142	8.485557
612	374544	229220928	24.7386338	8.490184
613	375769	230346397	24.7588368	8.494806
614	376996	231475544	24.7790234	8.499423
615	378225	232608375	24.7991935	8.504034
616	379456	233744896	24.8193473	8.508641
617	380689	234885113	24.8394847	8.513243
618	381924	236029032	24.8596058	8.517840
619	383161	237176659	24.8797106	8.522432
620	384400	238328000	24.8997992	8.527018
621	385641	239483061	24.9198716	8.531600
622	386884	240641848	24.9399278	8.536177
623	388129	241804367	24.9599679	8.540749
624	389376	242970624	24.9799920	8.545317
625	390625	244140625	25.0000000	8.549879
626	391876	245314376	25.0199920	8.554437
627	393129	246491883	25.0399681	8.558990
628	394384	247673152	25.0599282	8.563537
629	395641	248858189	25.0798724	8.568080
630	396900	250047000	25.0998008	8.572618
631	398161	251239591	25.1197134	8.577152
632	399424	252435968	25.1396102	8.581680
633	400689	253636137	25.1594913	8.586204
634	401956	254840104	25.1793566	8.590723
635	403225	256047875	25.1992063	8.595238
636	404496	257259456	25.2190404	8.599747
637	405769	258474853	25.2388589	8.604252
638	407044	259694072	25.2586619	8.608752
639	408321	260917119	25.2784403	8.613248
640	409600	262144000	25.2982213	8.617738
641	410881	263374721	25.3179778	8.622224
642	412164	264609288	25.3377189	8.626706
643	413449	265847707	25.3574447	8.631183
644	414736	267089984	25.3771551	8.635655
645	416025	268336125	25.3968502	8.640122
646	417316	269586136	25.4165301	8.644585
647	418609	270840023	25.4361947	8.649043
648	419904	272097792	25.4558441	8.653497
649	421201	273359449	25.4754784	8.657946
650	422500	274625000	25.4950076	8.662301

Number.	Square.	Cube.	Square Root.	Cube Root.
651	423801	275894451	25.5147016	8.666831
652	425104	277167808	25.5342907	8.671266
653	426409	278445077	25.5538647	8.675697
654	427716	279726264	25.5734237	8.680123
655	429025	281011375	25.5929678	8.684545
656	430336	282300416	25.6124969	8.688963
657	431649	283593393	25.6320112	8.693376
658	432964	284890312	25.6515107	8.697784
659	434281	286191179	25.6709953	8.702188
660	435600	287496000	25.6904652	8.706587
661	436921	288804781	25.7099203	8.710982
662	438244	290117528	22.7203607	8.715373
663	439569	291434247	25.7487864	8.719759
664	440896	292754944	25.7681975	8.724141
665	442225	294079625	25.7875939	8.728518
666	443556	295408296	25.8069758	8.732891
667	444889	296740963	25.8263431	8.737260
668	446224	298077632	25.8456960	8.741624
669	447561	299418309	25.8650343	8.745984
670	448900	300763000	25.8843582	8.750340
671	450241	302111711	25.9036677	8.754691
672	451584	303464448	25.9229628	8.759038
673	452929	304821217	25.9422435	8.763380
674	454276	306182024	25.9615100	8.767719
675	455625	307546875	25.9807621	8.772053
676	456976	308915776	26.0000000	8.776382
677	458329	310288733	26.0192237	8.780708
678	459684	311665752	26.0384331	8.785029
679	461041	313046839	26.0576284	8.789346
680	462400	314432000	26.0768096	8.793659
681	463761	315821241	26.0959767	8.797967
682	465124	317214568	26.1151297	8.802272
683	466489	318611987	26.1342687	8.806572
684	467856	320013504	26.1533937	8.810868
685	469225	321419125	26.1725047	8.815159
686	470596	322828856	26.1916017	8.819447
687	471969	324242703	26.2106848	8.823730
688	473344	325660672	26.2297541	8.828009
689	474721	327082769	26.2488095	8.832285
690	476100	328509000	26.2678511	8.836556
691	477481	329939371	26.2868789	8.840822
692	478864	331373888	26.3058929	8.845085
693	480249	332812557	26.3248932	8.849344
694	481636	334255384	26.3438797	8.853598
695	483025	335702375	26.3628527	8.857849
696	484416	337153536	26.3818119	8.862095
697	485809	338608873	26.4007576	8.866337
698	487204	340068392	26.4196896	8.870575
699	488601	341532099	26.4386081	8.874809
700	490000	343000000	26.4575131	8.879040

Number.	Square.	Cube.	Square Root.	Cube Root.
701	491401	344472101	26.4764046	8.883266
702	492804	345948008	26.4952826	8.887488
703	494209	347428927	26.5141472	8.891706
704	495616	348913664	26.5320983	8.895920
705	497025	350402625	26.5518361	8.900130
706	498436	351895816	26.5706605	8.904336
707	499849	353393243	26.5894716	8.908538
708	501264	354894912	26.6082694	8.912736
709	502681	356400829	26.6270539	8.916931
710	504100	357911000	26.6458252	8.921121
711	505521	359425431	26.6645833	8.925307
712	506944	360944128	26.6833281	8.929490
713	508369	362467097	26.7020598	8.933668
714	509796	363994344	26.7207784	8.937843
715	511225	365525875	26.7394839	8.942014
716	512656	367061696	26.7581763	8.946180
717	514089	368601813	26.7768557	8.950343
718	515524	370146232	26.7955220	8.954502
719	516961	371694959	26.8141754	8.958658
720	518400	373248000	26.8328157	8.962809
721	519841	374805361	26.8514432	8.966957
722	521284	376367018	26.8700577	8.971100
723	522729	377933067	26.8886593	8.975240
724	524176	379503424	26.9072481	8.979376
725	525625	381078125	26.9258240	8.983508
726	527076	382657176	26.9443872	8.987637
727	528529	384240583	26.9629375	8.991762
728	529984	385828352	26.9814751	8.995883
729	531441	387420489	27.0000000	9.000000
730	532900	389017000	27.0185122	9.004113
731	534361	390617891	27.0370117	9.008222
732	535824	392223168	27.0554985	9.012328
733	537289	393832837	27.0739727	9.016430
734	538756	395446904	27.0924344	9.020529
735	540225	397065375	27.1108834	9.024623
736	541696	398688256	27.1293199	9.028714
737	543169	400315553	27.1477439	9.032802
738	544644	401947272	27.1661554	9.036885
739	546121	403583419	27.1845544	9.040965
740	547600	405224000	27.2029410	9.045041
741	549081	406869021	27.2213152	9.049114
742	550564	408518488	27.2396769	9.053183
743	552049	410172407	27.2580263	9.057248
744	553536	411830784	27.2763634	9.061309
745	555025	413493625	27.2946881	9.065367
746	556516	415160936	27.3130006	9.069422
747	558009	416832723	27.3313007	9.073472
748	559504	418508992	27.3495887	9.077519
749	561001	420189749	27.3678644	9.081563
750	562500	421875000	27.3861279	9.085603

Number.	Square.	Cube.	Square Root.	Cube Root.
751	564001	423564751	27.4043792	9.089639
752	565504	425259008	27.4226184	9.093672
753	567009	426957777	27.4408455	9.097701
754	568516	428661064	27.4590604	9.101726
755	570025	430368875	27.4772633	9.105748
756	571536	432081216	27.4954542	9.109766
757	573049	433798093	27.5136330	9.113781
758	574564	435519512	27.5317998	9.117793
759	576081	437245479	27.5499546	9.121801
760	577600	438976000	27.5680975	9.125805
761	579121	440711081	27.5862284	9.129806
762	580644	442450728	27.6043475	9.133803
763	582169	444194947	27.6224546	9.137797
764	583696	445943744	27.6405499	9.141788
765	585225	447697125	27.6586334	9.145774
766	586756	449455096	27.6767050	9.149757
767	588289	451217663	27.6947648	9.153737
768	589824	452984832	27.7128129	9.157713
769	591361	454756609	27.7308492	9.161686
770	592900	456533000	27.7488739	9.165656
771	594441	458314011	27.7668868	9.169622
772	595984	460099648	27.7848880	9.173585
773	597529	461889917	27.8028775	9.177544
774	599076	463684824	27.8208555	9.181500
775	600625	465484375	27.8388218	9.185452
776	602176	467288576	27.8567766	9.189401
777	603729	469097433	27.8747197	9.193347
778	605284	470910952	27.8926514	9.197289
779	606841	472729139	27.9105715	9.201228
780	608400	474552000	27.9284801	9.205164
781	609961	476379541	27.9463772	9.209096
782	611524	478211768	27.9642629	9.213025
783	613089	480048687	27.9821372	9.216950
784	614656	481890304	28.0000000	9.220872
785	616225	483736025	28.0178515	9.224791
786	617796	485587656	28.0356915	9.228706
787	619369	487443403	28.0535203	9.232618
788	620944	489303872	28.0713377	9.237527
789	622521	491169069	28.0891438	9.240433
790	624100	493039000	28.1069386	9.244335
791	625681	494913671	28.1247222	9.248234
792	627264	496793088	28.1424946	9.252130
793	628849	498677257	28.1602557	9.256022
794	630436	500566184	28.1780056	9.259911
795	632025	502459875	28.1957444	9.263797
796	633616	504358336	28.2134720	9.267679
797	635209	506261573	28.2311884	9.271559
798	636804	508169592	28.2488938	9.275435
799	638401	510082399	28.2665881	9.279308
800	640000	512000000	28.2842712	9.283177

Number.	Square.	Cube.	Square Root.	Cube Root.
801	641601	513922401	28.3019434	9.287044
802	643204	515849608	28.3196045	9.290907
803	644809	517781627	28.3372546	9.294767
804	646416	519718464	28.3548938	9.298623
805	648025	521660125	28.3725219	9.302477
806	649636	523606616	28.3901391	9.306327
807	651249	525557943	28.4077454	9.310175
808	652864	527514112	28.4253408	9.314019
809	654481	529475129	28.4429253	9.317859
810	656100	531441000	28.4604989	9.321697
811	657721	533411731	28.4780617	9.325532
812	659344	535387328	28.4956137	9.329363
813	660969	537366797	28.5131549	9.333191
814	662596	539353144	28.5306852	9.337016
815	664225	541343375	28.5482048	9.340838
816	665856	543338496	28.5657137	9.344657
817	667489	545338513	28.5832119	9.348473
818	669124	547343432	28.6006993	9.352285
819	670761	549353259	28.6181760	9.356095
820	672400	551368000	28.6356421	9.359901
821	674041	553387661	28.6530976	9.363704
822	675684	555412248	28.6705424	9.367505
823	677329	557441767	28.6879766	9.371302
824	678976	559476224	28.7054002	9.375096
825	680625	561515625	28.7228132	9.378887
826	682276	563559976	28.7402157	9.382675
827	683929	565609283	28.7576077	9.386460
828	685584	567663552	28.7749891	9.390241
829	687241	569722789	28.7923601	9.394020
830	688900	571787000	28.8097206	9.397796
831	690561	573856191	28.8270706	9.401569
832	692224	575930368	28.8444102	9.405338
833	693889	578009537	28.8617394	9.409105
834	695556	580093704	28.8790582	9.412869
835	697225	582182875	28.8963666	9.416630
836	698896	584277056	28.9136646	9.420387
837	700569	586376253	28.9309523	9.424141
838	702244	588480472	28.9482297	9.427893
839	703921	590589719	28.9654967	9.431642
840	705600	592704000	29.9827535	9.435388
841	707281	594823321	29.0000000	9.439130
842	708964	596947688	29.0172363	9.442870
843	710649	599077107	29.0344623	9.446607
844	712336	601211584	29.0516781	9.450341
845	714025	603351125	29.0688837	9.454071
846	715716	605495736	29.0860791	9.457799
847	717409	607645423	29.1032644	9.461524
848	719104	609800192	29.1204396	9.465247
849	720801	611960049	29.1376046	9.468966
850	722500	614125000	29.1547595	9.472682

Number.	Square.	Cube.	Square Root.	Cube Root.
851	724201	616295051	29.1719043	9.476395
852	725904	618470208	29.1890390	9.480106
853	727609	620650477	29.2061637	9.483813
854	729316	622835864	29.2232784	9.487518
855	731025	625026375	29.2403830	9.491219
856	732736	627222016	29.2574777	9.494918
857	734449	629422793	29.2745623	9.498614
858	736164	631628712	29.2916370	9.502307
859	737881	633839779	29.3087018	9.505998
860	739600	636056000	29.3257566	9.509685
861	741321	638277381	29.3428015	9.513369
862	743044	640503928	29.3598365	9.517051
863	744769	642735647	29.3768616	9.520730
864	746496	644972544	29.3938769	9.524406
865	748225	647214625	29.4108823	9.528079
866	749956	649461896	29.4278779	9.531749
867	751689	651714363	29.4448637	9.535417
868	753424	653972032	29.4618397	9.539081
869	755161	656234909	29.4788059	9.542743
870	756900	658503000	29.4957624	9.546402
871	758641	660776311	29.5127091	9.550058
872	760384	663054848	29.5296461	9.553712
873	762129	665338617	29.5465734	9.557363
874	763876	667627624	29.5634910	9.561010
875	765625	669921875	29.5803989	9.564655
876	767376	672221376	29.5972972	9.568297
877	769129	674526133	29.6141858	9.571937
878	770884	676836152	29.6310648	9.575574
879	772641	679151439	29.6479325	9.579208
880	774400	681472000	29.6647939	9.582839
881	776161	683797841	29.6816442	9.586468
882	777924	686128968	29.6984848	9.590093
883	779689	688465387	29.7153159	9.593716
884	781456	690807104	29.7321375	9.597337
885	783225	693154125	29.7489496	9.600954
886	784996	695506456	29.7657521	9.604569
887	786769	697864103	29.7825452	9.608181
888	788544	700227072	29.7993289	9.611791
889	790321	702595369	29.8161030	9.615397
890	792100	704969000	29.8328678	9.619001
891	793881	707347971	29.8496231	9.622603
892	795664	709732288	29.8663690	9.626201
893	797449	712121957	29.8831056	9.629797
894	799236	714516984	29.8998328	9.633390
895	801025	716917375	29.9165506	9.636981
896	802816	719323136	29.9332591	9.640569
897	804609	721734273	29.9499583	9.644154
898	806404	724150792	29.9666481	9.647736
899	808201	726572699	29.9833287	9.651316
900	810000	729000000	30.0000000	9.654893

Number.	Square.	Cube.	Square Root.	Cube Root.
901	811801	731432701	30.0166620	9.658468
902	813604	733870808	30.0333148	9.662040
903	815409	736314327	30.0499584	9.665609
904	817216	738763264	30.0665928	9.669176
905	819025	741217625	30.0832179	9.672740
906	820836	743677416	30.0998339	9.676301
907	822649	746142643	30.1164407	9.679860
908	824464	748613312	30.1330383	9.683416
909	826281	751089429	30.1496269	9.686970
910	828100	753571000	30.1662063	9.690521
911	829921	756058031	30.1827765	9.694069
912	831744	758550528	30.1993377	9.697615
913	833569	761048497	30.2158899	9.701158
914	835396	763551944	30.2324329	9.704698
915	837225	766060875	30.2489669	9.708236
916	839056	768575296	30.2654919	9.711772
917	840889	771095213	30.2820079	9.715305
918	842724	773620632	30.2985148	9.718835
919	844561	776151559	30.3150128	9.722363
920	846400	778688000	30.3315018	9.725888
921	848241	781229961	30.3479818	9.729410
922	850084	783777448	30.3644529	9.732930
923	851929	786330467	30.3809151	9.736448
924	853776	788889024	30.3973683	9.739963
925	855625	791453125	30.4138127	9.743475
926	857476	794022776	30.4302481	9.746985
927	859329	796597983	30.4466747	9.750493
928	861184	799178752	30.4630924	9.753998
929	863041	801765089	30.4795013	9.757500
930	864900	804357000	30.4959014	9.761000
931	866761	806954491	30.5122926	9.764497
932	868624	809557568	30.5286750	9.767992
933	870489	812166237	30.5450487	9.771484
934	872356	814780504	30.5614136	9.774974
935	874225	817400375	30.5777697	9.778461
936	876096	820025856	30.5941171	9.782946
937	877969	822656953	30.6104557	9.785428
938	879844	825293672	30.6267857	9.788908
939	881721	827936019	30.6431069	9.792386
940	883600	830584000	30.6594194	9.795861
941	885481	833237621	30.6757233	9.799333
942	887364	835896888	30.6920185	9.802803
943	889249	838561807	30.7083051	9.806271
944	891136	841232384	30.7245830	9.809736
945	893025	843908625	30.7408523	9.813198
946	894916	846590536	30.7571130	9.816659
947	896809	849278123	30.7733651	9.820117
948	898704	851971392	30.7896086	9.823572
949	900601	954670349	30.8058436	9.827025
950	902500	957375000	30.8220700	9.830475

Number.	Square.	Cube.	Square Root.	Cube Root.
951	904401	860085351	30.8382879	9.833923
952	906304	862801408	30.8544972	9.837369
953	908209	865523177	30.8706981	9.840812
954	910116	868250664	30.8868904	9.844253
955	912025	870983875	30.9030743	9.847692
956	913936	873722816	30.9192497	9.851128
957	915849	876467493	30.9354166	9.854561
958	917764	879217912	30.9515751	9.857992
959	919681	881974079	30.9677251	9.861421
960	921600	884736000	30.9838668	9.864848
961	923521	887503681	31.0000000	9.868272
962	925444	890277128	31.0161248	9.871694
963	927369	893056347	31.0322413	9.875113
964	929296	895841344	31.0483494	9.878530
965	931225	898632125	31.0644491	9.881945
966	933156	901428696	31.0805405	9.885357
967	935089	904231063	31.0966236	9.888767
968	937024	907039232	31.1126984	9.892174
969	938961	909853209	31.1287648	9.895580
970	940900	912673000	31.1448230	9.898983
971	942841	915498611	31.1608729	9.902383
972	944784	918330048	31.1769145	9.905781
973	946729	921167317	31.1929479	9.909177
974	948676	924010424	31.2089731	9.912571
975	950625	926859375	31.2249900	9.915962
976	952576	929714176	31.2409987	9.919351
977	954529	932574833	31.2569992	9.922738
978	956484	935441352	31.2729915	9.926122
979	958441	938313739	31.2889757	9.929504
980	960400	941192001	31.3049517	9.932883
981	962361	944076141	31.3209195	9.936261
982	964324	946966168	31.3368792	9.939636
983	966289	949862087	31.3528308	9.943009
984	968256	952763904	31.3687743	9.940379
985	970225	955671625	31.3847097	9.949747
986	972196	958585256	31.4006369	9.953113
987	974169	961504803	31.4165561	9.956477
988	976144	964430272	31.4324673	9.959839
989	978121	967361669	31.4483704	9.963198
990	980100	970299000	31.4642654	9.966454
991	982081	973242271	31.4801525	9.969909
992	984064	976191488	31.4960315	9.973262
993	986049	979146657	31.5119025	9.976612
994	988036	982107784	31.5277655	9.979959
995	990025	985074875	31.5436206	9.983304
996	992016	988047936	31.5594677	9.986648
997	994009	991026973	31.5753068	9.989990
998	996004	994011992	31.5911380	9.993328
999	998001	997002999	31.6069613	9.996665
1000	1000000	1000000000	31.6227767	10.000000

Specific Gravities.

SOLIDS.	Specific gravity.	Weight of 1 cubic inch.	SOLIDS.	Specific gravity.	Weight of 1 cubic inch.
		Lbs.			Lbs.
Antimony, cast -	6,712	0.2428	Salt, common -	2,130	0.0774
Brass, cast -	8,396	0.3037	Saltpetre -	2,090	0.0756
Bronze, gun metal -	8,700	0.3147	Sand -	1,800	0.0652
Copper, cast -	8,788	0.3179	Slate -	2,672	0.0959
Do. wire -	8,878	0.3211	Stone, common -	2,520	0.0911
Gold, cast -	19,258	0.6966	Sulphur, native -	2,033	0.0735
Do. hammered -	19,361	0.7003	Tallow -	945	0.0342
Iron, bar -	7,788	0.2817	Wood, (dry,) Apple -	793	0.0269
Do. cast -	7,207	0.2607	Ash -	845	0.0306
Lead, cast -	11,352	0.4106	Beech -	852	0.0308
Mercury, at 32° -	13,598	0.4918	Box -	912	0.0330
Do. at 60° -	13,580	0.4912	Cedar -	596	0.0216
Platinum, rolled -	22,069	0.7982	Cherry -	715	0.0259
Do. hammered -	20,337	0.7356	Cork -	240	0.0087
Silver, cast -	10,474	0.3788	Cypress -	644	0.0233
Do. hammered -	10,511	0.3806	Elm -	671	0.0243
Steel, soft -	7,833	0.2833	Fir -	700	0.0253
Do. hardened and tempered -	7,818	0.2828	Lignum vitæ -	1,333	0.0482
Tin, cast -	7,291	0.2637	Mahogany -	854	0.0309
Zinc, cast -	6,861	0.2482	Maple -	750	0.0271
Amber -	1,078	0.0390	Oak, English -	932	0.0337
Beeswax -	965	0.0349	Do. do. heart, 60 years old -	1,170	0.0423
Bricks -	1,900	0.0690	Pine, yellow -	660	0.0239
Borax -	1,714	0.0620	Do. white -	554	0.0200
Camphor -	989	0.0358	Poplar -	383	0.0139
Chalk -	2,784	0.1007	Walnut -	671	0.0243
Charcoal -	441	0.0160	Ash -	722	0.0261
Do. triturated -	1,380	0.0499	Beech -	624	0.0226
Clay -	1,930	0.0700	Cherry -	606	0.0219
Coal, bituminous -	1,270	0.0460	Cypress -	441	0.0160
Diamond -	3,521	0.1274	Hickory, red -	838	0.0303
Earth, common -	1,500	0.0543	Mahogany, (St. Domingo) -	720	0.0260
Gunpowder, loose -	900	0.0326	Oak, white, (Upland) -	687	0.0248
Do. shaken -	1,000	0.0362	Oak, white (James river) -	759	0.0275
Do. solid -	1,550	0.0561	Pine, yellow -	541	0.0196
Gypsum -	2,168	0.0784	Do. white -	473	0.0171
Ivory -	1,822	0.0659	Poplar, (Tulip tree) -	587	0.0212
Limestone -	3,180	0.1150			
Lime, quick -	804	0.0291			
Marble, Parian -	2,838	0.1027			
Do. common -	2,686	0.0972			

Samples of well seasoned American Wood, (1839.)

Specific Gravities—Continued.

LIQUIDS.			Specific gravity.	ELASTIC FLUIDS.			Specific gravity.
Acid, nitric	-	-	1,217	Air, atmospheric	-	-	1 000
Do. sulphuric	-	-	1,841	Ammoniacal gas	-	-	597
Alcohol, absolute	-	-	792	Azote	-	-	976
Ether, sulphuric	-	-	715	Carbonic acid	-	-	1,524
Oil, linseed	-	-	940	Carburetted hydrogen	-	-	555
Do. olive	-	-	915	Chlorine	-	-	2,470
Do. essential, of turpentine	-	-	870	Chloro-carbonic	-	-	3,389
Do. whale	-	-	923	Hydrogen	-	-	70
Turpentine, liquid	-	-	991	Oxygen	-	-	1,104
Water, distilled	-	-	1,000	Phosphuretted hydrogen	-	-	870
Do. sea	-	-	1,026	Sulphuretted hydrogen	-	-	1,777
Wine	-	-	992	Sulphurous acid	-	-	2,120
				Vapor of alcohol	-	-	1,613
				Do. spirits of turpentine	-	-	5,013
				Do. sulphuric ether	-	-	2,586
				Do. water	-	-	623

The weight of a cubic foot of distilled water *at the maximum density* being nearly 1,000 ounces Avoirdupois, the specific gravity of a body expresses the weight of a cubic foot, in ounces ; therefore the weight of a body in ounces will be found by multiplying its contents in cubic feet by its specific gravity.

The weight of dry atmospheric air at the temperature of 32°, the barometer at 30 in., is $\frac{1}{770}$ of that of distilled water.

Weight of one foot in length of malleable round Iron.

Diam.	Weight.	Diam.	Weight.	Diam.	Weight.	Diam.	Weight.
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
0.25	0.163	1.75	8.01	3.25	27.65	4.75	59.06
0.375	0.368	1.875	9.2	3.375	29.82	4.875	62.21
0.5	0.654	2.	10.47	3.5	32.07	5.	65.45
0.625	1.02	2.125	11.82	3.625	34.4	5.125	68.76
0.75	1.47	2.25	13.25	3.75	36.81	5.25	72.16
0.875	2.	2.375	14.76	3.875	39.31	5.375	75.63
1.	2.61	2.5	16.36	4.	41.89	5.5	79.19
1.125	3.31	2.625	18.03	4.125	44.54	5.625	82.83
1.25	4.09	2.75	19.79	4.25	47.28	5.75	86.56
1.375	4.94	2.875	21.63	4.375	50.11	5.875	90.36
1.5	5.89	3.	23.56	4.5	53.01	6.	94.25
1.625	6.91	3.125	25.56	4.625	56.	6.185	100.

Weight of one foot in length of malleable flat and square Iron.

Width.	Thickness.	Weight.	Width.	Thick- ness.	Weight.	Width.	Thickness.	Weight.
In.	In.	Lbs.	In.	In.	Lbs.	In.	In.	Lbs.
0.25	0.25	0.21	1.375	0.75	3.46	2.0	1.125	7.56
0.375	0.375	0.47	1.5	0.875	4.04	2.125	1.25	8.40
0.5	0.125	0.21	1.625	1.0	4.62	2.25	1.375	9.24
0.625	0.1875	0.31	1.75	1.125	5.19	2.375	1.5	10.08
0.75	0.25	0.42	1.875	1.25	5.77	2.5	1.75	11.76
0.875	0.375	0.63	2.0	1.375	6.35	2.625	2.0	13.44
1.0	0.5	0.84	2.125	0.125	0.63	2.75	0.125	0.94
1.125	0.625	1.34	2.25	0.1875	0.94	2.875	0.1875	1.41
1.25	0.75	0.31	2.375	0.25	1.26	3.0	0.25	1.89
1.375	0.875	0.47	2.5	0.375	1.89	3.125	0.375	2.83
1.5	1.0	0.63	2.625	0.5	2.52	3.25	0.5	3.78
1.625	1.125	0.94	2.75	0.625	3.15	3.375	0.625	4.72
1.75	1.25	1.26	2.875	0.75	3.78	3.5	0.75	5.66
1.875	1.375	1.57	3.0	0.875	4.41	3.625	0.875	6.61
2.0	1.5	1.89	3.125	1.0	5.04	3.75	1.0	7.56
2.125	1.625	2.57	3.25	1.125	5.67	3.875	1.125	8.50
2.25	1.75	0.42	3.375	1.25	6.30	4.0	1.25	9.45
2.375	1.875	0.63	3.5	1.5	7.56	4.125	1.375	10.39
2.5	2.0	0.84	3.625	1.625	8.87	4.25	1.5	11.34
2.625	2.125	1.26	3.75	1.75	10.08	4.375	1.75	13.22
2.75	2.25	1.68	3.875	1.875	11.76	4.5	2.0	15.12
2.875	2.375	2.10	4.0	2.0	14.00	4.625	2.25	17.01
3.0	2.5	2.52	4.125	2.125	15.87	4.75	2.5	19.00
3.125	2.625	2.94	4.25	2.25	17.81	4.875	2.75	21.16
3.25	2.75	3.36	4.375	2.375	19.82	5.0	3.0	23.52
3.375	2.875	3.78	4.5	2.5	21.87	5.125	3.25	26.00
3.5	3.0	4.20	4.625	2.625	24.00	5.25	3.5	28.50
3.625	3.125	4.62	4.75	2.75	26.19	5.375	3.75	31.00
3.75	3.25	5.04	4.875	2.875	28.44	5.5	4.0	33.60
3.875	3.375	5.46	5.0	3.0	30.75	5.625	4.25	36.20
4.0	3.5	5.88	5.125	3.125	33.12	5.75	4.5	38.90
4.125	3.625	6.30	5.25	3.25	35.56	5.875	4.75	41.60
4.25	3.75	6.72	5.375	3.375	38.07	6.0	5.0	44.40
4.375	3.875	7.14	5.5	3.5	40.62	6.125	5.25	47.20
4.5	4.0	7.56	5.625	3.625	43.24	6.25	5.5	50.00
4.625	4.125	7.98	5.75	3.75	45.92	6.375	5.75	52.80
4.75	4.25	8.40	5.875	3.875	48.67	6.5	6.0	55.70
4.875	4.375	8.82	6.0	4.0	51.50	6.625	6.25	58.70
5.0	4.5	9.24	6.125	4.125	54.40	6.75	6.5	61.80
5.125	4.625	9.66	6.25	4.25	57.37	6.875	6.75	64.90
5.25	4.75	10.08	6.375	4.375	60.42	7.0	7.0	68.10
5.375	4.875	10.50	6.5	4.5	63.54	7.125	7.25	71.40
5.5	5.0	10.92	6.625	4.625	66.74	7.25	7.5	74.80
5.625	5.125	11.34	6.75	4.75	69.99	7.375	7.75	78.30
5.75	5.25	11.76	6.875	4.875	73.32	7.5	8.0	81.90
5.875	5.375	12.18	7.0	5.0	76.72	7.625	8.25	85.60
6.0	5.5	12.60	7.125	5.125	80.19	7.75	8.5	89.40
6.125	5.625	13.02	7.25	5.25	83.74	7.875	8.75	93.30
6.25	5.75	13.44	7.375	5.375	87.36	8.0	9.0	97.30
6.375	5.875	13.86	7.5	5.5	91.05	8.125	9.25	101.40
6.5	6.0	14.28	7.625	5.625	94.82	8.25	9.5	105.60
6.625	6.125	14.70	7.75	5.75	98.66	8.375	9.75	109.90
6.75	6.25	15.12	7.875	5.875	102.58	8.5	10.0	114.30
6.875	6.375	15.54	8.0	6.0	106.57	8.625	10.25	118.80
7.0	6.5	15.96	8.125	6.125	110.64	8.75	10.5	123.40
7.125	6.625	16.38	8.25	6.25	114.78	8.875	10.75	128.10
7.25	6.75	16.80	8.375	6.375	118.99	9.0	11.0	132.90
7.375	6.875	17.22	8.5	6.5	123.27	9.125	11.25	137.80
7.5	7.0	17.64	8.625	6.625	127.62	9.25	11.5	142.80
7.625	7.125	18.06	8.75	6.75	132.04	9.375	11.75	147.90
7.75	7.25	18.48	8.875	6.875	136.54	9.5	12.0	153.10
7.875	7.375	18.90	9.0	7.0	141.10	9.625	12.25	158.40
8.0	7.5	19.32	9.125	7.125	145.74	9.75	12.5	163.80
8.125	7.625	19.74	9.25	7.25	150.45	9.875	12.75	169.30
8.25	7.75	20.16	9.375	7.375	155.24	10.0	13.0	174.90
8.375	7.875	20.58	9.5	7.5	160.10	10.125	13.25	180.60
8.5	8.0	21.00	9.625	7.625	165.04	10.25	13.5	186.40
8.625	8.125	21.42	9.75	7.75	170.05	10.375	13.75	192.30
8.75	8.25	21.84	9.875	7.875	175.14	10.5	14.0	198.30
8.875	8.375	22.26	10.0	8.0	180.30	10.625	14.25	204.40
9.0	8.5	22.68	10.125	8.125	185.54	10.75	14.5	210.60
9.125	8.625	23.10	10.25	8.25	190.85	10.875	14.75	216.90
9.25	8.75	23.52	10.375	8.375	196.24	11.0	15.0	223.30
9.375	8.875	23.94	10.5	8.5	201.70	11.125	15.25	229.80
9.5	9.0	24.36	10.625	8.625	207.24	11.25	15.5	236.40
9.625	9.125	24.78	10.75	8.75	212.85	11.375	15.75	243.10
9.75	9.25	25.20	10.875	8.875	218.54	11.5	16.0	249.90
9.875	9.375	25.62	11.0	9.0	224.30	11.625	16.25	256.80
10.0	9.5	26.04	11.125	9.125	230.14	11.75	16.5	263.80
10.125	9.625	26.46	11.25	9.25	236.05	11.875	16.75	270.90
10.25	9.75	26.88	11.375	9.375	242.04	12.0	17.0	278.10
10.375	9.875	27.30	11.5	9.5	248.10	12.125	17.25	285.40
10.5	10.0	27.72	11.625	9.625	254.24	12.25	17.5	292.80
10.625	10.125	28.14	11.75	9.75	260.45	12.375	17.75	300.30
10.75	10.25	28.56	11.875	9.875	266.74	12.5	18.0	307.90
10.875	10.375	28.98	12.0	10.0	273.10	12.625	18.25	315.60
11.0	10.5	29.40	12.125	10.125	279.54	12.75	18.5	323.40
11.125	10.625	29.82	12.25	10.25	286.05	12.875	18.75	331.30
11.25	10.75	30.24	12.375	10.375	292.64	13.0	19.0	339.30
11.375	10.875	30.66	12.5	10.5	299.30	13.125	19.25	347.40
11.5	11.0	31.08	12.625	10.625	306.04	13.25	19.5	355.60
11.625	11.125	31.50	12.75	10.75	312.85	13.375	19.75	363.90
11.75	11.25	31.92	12.875	10.875	319.74	13.5	20.0	372.30
11.875	11.375	32.34	13.0	11.0	326.70	13.625	20.25	380.80
12.0	11.5	32.76	13.125	11.125	333.74	13.75	20.5	389.40
12.125	11.625	33.18	13.25	11.25	340.85	13.875	20.75	398.10
12.25	11.75	33.60	13.375	11.375	348.04	14.0	21.0	406.90
12.375	11.875	34.02	13.5	11.5	355.30	14.125	21.25	415.80
12.5	12.0	34.44	13.625	11.625	362.64	14.25	21.5	424.80
12.625	12.125	34.86	13.75	11.75	370.05	14.375	21.75	433.90
12.75	12.25	35.28	13.875	11.875	377.54	14.5	22.0	443.10
12.875	12.375	35.70	14.0	12.0	385.10	14.625	22.25	452.40
13.0	12.5	36.12	14.125	12.125	392.74	14.75	22.5	461.80
13.125	12.625	36.54	14.25	12.25	400.45	14.875	22.75	471.30
13.25	12.75	36.96	14.375	12.375	408.24	15.0	23.0	480.90
13.375	12.875	37.38	14.5	12.5	416.10	15.125	23.25	490.60
13.5	13.0	37.80	14.625	12.625	424.04	15.25	23.5	500.40
13.625	13.125	38.22	14.75	12.75	432.05	15.375	23.75	510.30
13.75	13.25	38.64	14.875	12.875	440.14	15.5	24.0	520.30
13.875	13.375	39.06	15.0	13.0	448.30	15.625	24.25	530.40
14.0	13.5	39.48	15.125	13.125	456.54	15.75	24.5	540.60
14.125	13.625	39.90	15.25	13.25	464.85	15.875	24.75	550.90
14.25	13.75	40.32	15.375	13.375	473.24	16.0	25.0	561.30
14.375	13.875	40.74	15.5	13.5	481.70	16.125	25.25	571.80
14.5	14.0	41.16	15.625	13.625	490.24	16.25	25.5	582.40
14.625	14.125	41.58	15.75	13.75	498.85	16.375	25.75	593.10
14.75	14.25	42.00	15.875	13.875	507.54	16.5	26.0	603.90
14.875	14.375	42.42	16.0	14.0	516.30	16.625	26.25	614.80
15.0	14.5	42.84	16.125	14.125	525.14	16.75	26.5	625.80
15.125	14.625	43.26	16.25	14.25	534.05	16.875	26.75	636.90
15.25	14.75	43.68	16.375	14.375	543.04	17.0	27.0	648.10
15.375	14.875	44.10	16.5	14.5	552.10	17.125	27.25	659.40
15.5	15.0	44.52	16.625	14.625	561.24	17.25	27.5	670.80
15.625	15.125	44.94	16.75	14.75	570.45	17.375	27.75	682.30
15.75	15.25	45.36	16.875	14.875	579.74	17.5	28.0	693.90
15.875	15.375	45.78	17.0	15.0	589.10	17.625	28.25	705.60
16.0	15.5	46.20	17.125	15.125	598.54	17.75	28.5	717.40
16.125	15.625	46.62	17.25	15.25	608.05	17.875	28.75	729.30
16.25	15.75	47.04	17.375	15.375	617.64	18.0	29.0	741.30
16.375	15.875	47.46	17.5	15.5	627.30	18.1		

Weight of flat and square Iron—Continued.

Width.	Thickness.	Weight.	Width.	Thick- ness.	Weight.	Width.	Thickness.	Weight.
In.	In.	Lbs.	In.	In.	Lbs.	In.	In.	Lbs.
2.75	0.875	8.08	3.25	0.75	8.19	3.75	0.625	7.87
.	1.	9.24	.	0.875	9.55	.	0.75	9.45
.	1.125	10.39	.	1.	10.92	.	0.875	11.02
.	1.25	11.55	.	1.125	12.28	.	1.	12.60
.	1.5	13.86	.	1.25	13.65	.	1.25	15.75
.	2.	18.48	.	1.5	16.38	.	1.5	18.90
.	2.5	23.10	.	2.	21.84	.	2.	25.20
.	2.75	25.41	.	2.5	27.39	.	2.5	31.50
3.	0.125	1.26	.	3.	32.76	.	3.	37.80
.	0.1875	1.89	3.5	0.125	1.47	4.	0.125	1.68
.	0.25	2.52	.	0.1875	2.20	.	0.1875	2.52
.	0.375	3.78	.	0.25	2.94	.	0.25	3.36
.	0.5	5.04	.	0.375	4.41	.	0.375	5.04
.	0.625	6.30	.	0.5	5.88	.	0.5	6.72
.	0.75	7.56	.	0.625	7.35	.	0.625	8.40
.	0.875	8.82	.	0.75	8.82	.	0.75	10.08
.	1.	10.08	.	0.875	10.29	.	0.875	11.76
.	1.125	11.34	.	1.	11.76	.	1.	13.44
.	1.25	12.60	.	1.25	14.70	.	1.25	16.80
.	1.5	15.12	.	1.5	17.64	.	1.5	20.18
.	2.	20.16	.	2.	23.52	.	2.	26.88
.	2.5	25.20	.	2.5	29.40	.	2.5	33.65
.	3.	30.24	.	3.	35.28	.	3.	40.32
3.25	0.125	1.36	.	3.5	41.16	.	3.5	47.04
.	0.1875	2.04	3.75	0.125	1.57	.	4.	53.76
.	0.25	2.73	.	0.1875	2.36	4.5	4.5	68.04
.	0.375	4.09	.	0.25	3.15	5.	5.	84.
.	0.5	5.46	.	0.375	4.72	6.	6.	120.96
.	0.625	6.82	.	0.5	6.30	7.	7.	164.64

Weight of one square foot of Iron Plate.

Thick- ness.	Weight.	Thick- ness.	Weight.	Thick- ness.	Weight	Thick- ness.	Weight.
In.	Lbs.	In.	Lbs.	In.	Lbs.	In.	Lbs.
0.01	0.406	0.06	2.434	0.1	4.057	0.6	24.344
0.02	0.811	0.07	2.840	0.2	8.114	0.7	28.401
0.03	1.217	0.08	3.246	0.3	12.172	0.8	32.458
0.04	1.623	0.09	3.651	0.4	16.232	0.9	36.516
0.05	2.029	0.10	4.057	0.5	20.286	1.	40.573

Multipliers for finding the Weights of other metals, from the preceding Tables.

Metals.	Multipliers.	Metals.	Multipliers.
Platinum, laminated	2.846	Copper, cast	1.128
Do. purified	2.503	Brass, wire	1.096
Pure gold, hammered	2.486	Do. cast	1.080
Do. cast	2.47	Steel	1.003
Lead	1.457	Iron, wrought	1.
Pure silver, hammered	1.350	Do. cast	0.925
Do. cast	1.344	Pewter	0.960
Copper, wire	1.136	Tin, cast	0.937
Do. hammered	1.132		

Weight of one square foot of different Metals.

THICKNESS.	WEIGHT.				
	Malleable Iron.	Cast Iron.	Copper.	Brass.	Lead.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0.0625	2.535	2.345	2.860	2.738	3.693
0.125	5.070	4.690	5.720	5.476	7.386
0.1875	7.605	7.035	8.580	8.214	11.079
0.25	10.140	9.380	11.440	10.952	14.772
0.3125	12.675	11.725	14.300	13.690	18.465
0.375	15.216	14.670	17.160	16.428	22.158
0.4375	17.851	16.415	20.020	19.166	25.851
0.5	20.280	18.760	22.880	21.904	29.544
0.5625	22.815	21.105	25.740	24.642	33.237
0.625	25.350	23.450	28.600	27.380	36.930
0.6875	27.885	25.795	31.640	30.118	40.623
0.75	30.410	28.140	34.320	32.856	44.316
0.8125	32.945	30.485	37.180	35.594	48.009
0.875	35.480	32.880	40.040	38.332	51.702
0.9375	38.015	35.225	42.900	41.170	55.405
1.	40.550	37.570	45.760	43.908	59.098

Weight of one foot in length of Cast Iron Pipes of different thicknesses.

DIAM. OF BORE.	$\frac{1}{4}$ Inch.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.
In.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	3.06	5.06	7.36	9.97	12.89	16.11	19.63
$1\frac{1}{4}$	3.68	5.98	8.59	11.51	14.73	18.25	22.09
$1\frac{1}{2}$	4.29	6.9	9.82	13.04	16.56	20.4	24.54
$1\frac{3}{4}$	4.91	7.83	11.05	14.57	18.41	22.55	27.
2	5.53	8.75	12.27	16.11	20.25	24.7	29.45
$2\frac{1}{4}$	6.14	9.66	13.5	17.64	22.09	26.84	31.85
$2\frac{1}{2}$	6.74	10.58	14.72	19.17	23.92	28.93	34.36
$2\frac{3}{4}$	7.36	11.5	15.95	20.7	25.71	31.14	36.81
3	7.98	12.43	17.18	22.19	27.62	33.29	39.28
$3\frac{1}{4}$	8.59	13.34	18.35	23.78	29.45	35.44	41.72
$3\frac{1}{2}$	9.2	14.21	19.64	25.31	31.3	37.58	44.18
$3\frac{3}{4}$	9.76	15.19	20.86	26.85	33.13	39.73	46.63
4	10.44	16.11	22.1	28.38	34.98	41.88	49.1
$4\frac{1}{4}$	11.1	17.08	23.37	29.97	36.87	44.08	51.6
$4\frac{1}{2}$	11.66	17.94	24.54	31.44	38.65	46.17	54.
$4\frac{3}{4}$	12.27	18.87	25.77	32.98	40.5	48.32	56.45
5	12.80	19.78	26.99	34.51	42.33	50.46	59.
$5\frac{1}{4}$	13.5	20.71	28.23	36.05	44.18	52.62	61.36
$5\frac{1}{2}$	14.11	21.63	29.45	37.58	46.02	54.76	63.81
$5\frac{3}{4}$	14.73	22.55	30.68	39.12	47.86	56.91	66.27
6	15.34	23.47	31.91	40.65	49.7	59.06	68.73
$6\frac{1}{4}$	15.95	24.39	33.13	42.18	51.54	61.21	72.
$6\frac{1}{2}$	16.57	25.31	34.36	43.72	53.39	63.36	73.41
$6\frac{3}{4}$	17.18	26.23	35.59	45.26	55.23	65.28	76.1
7	17.79	27.15	36.82	46.79	56.84	67.65	78.53
$7\frac{1}{4}$	18.41	28.08	38.05	48.1	58.91	69.79	81.
$7\frac{1}{2}$	19.03	29.	39.05	49.86	60.74	71.95	83.45
$7\frac{3}{4}$	19.64	29.69	40.5	51.38	62.59	74.09	86.
8	20.02	30.83	41.71	52.92	64.42	76.23	88.35
$8\frac{1}{4}$	20.86	31.74	42.95	54.45	66.26	78.38	90.81
$8\frac{1}{2}$	21.69	32.9	44.4	56.21	68.33	80.76	93.49
$8\frac{3}{4}$	22.09	33.59	45.4	57.52	69.95	82.68	95.72
9	22.71	34.52	46.64	59.07	71.8	84.84	98.18
$9\frac{1}{4}$	23.31	35.43	47.86	60.59	73.63	86.97	100.63
$9\frac{1}{2}$	23.93	36.36	49.09	62.13	75.47	89.13	103.1
$9\frac{3}{4}$	24.55	37.28	50.32	63.66	77.32	91.28	105.54
10	25.16	38.2	51.54	65.2	79.16	93.42	108.
$10\frac{1}{4}$	25.77	39.11	52.77	66.73	80.99	95.57	110.44
$10\frac{1}{2}$	26.38	40.04	54.	68.26	82.84	97.71	113.
$10\frac{3}{4}$	27.	40.96	55.22	69.8	84.67	99.86	115.35
11	27.62	41.88	56.46	71.33	86.52	102.01	117.81
$11\frac{1}{4}$	28.22	42.8	57.67	72.86	88.35	104.15	120.26
$11\frac{1}{2}$	28.84	43.71	58.9	74.39	90.19	106.3	122.71
$11\frac{3}{4}$	29.45	44.64	60.13	75.93	92.04	108.45	125.18
12	30.06	45.55	61.35	77.46	93.6	110.6	127.6

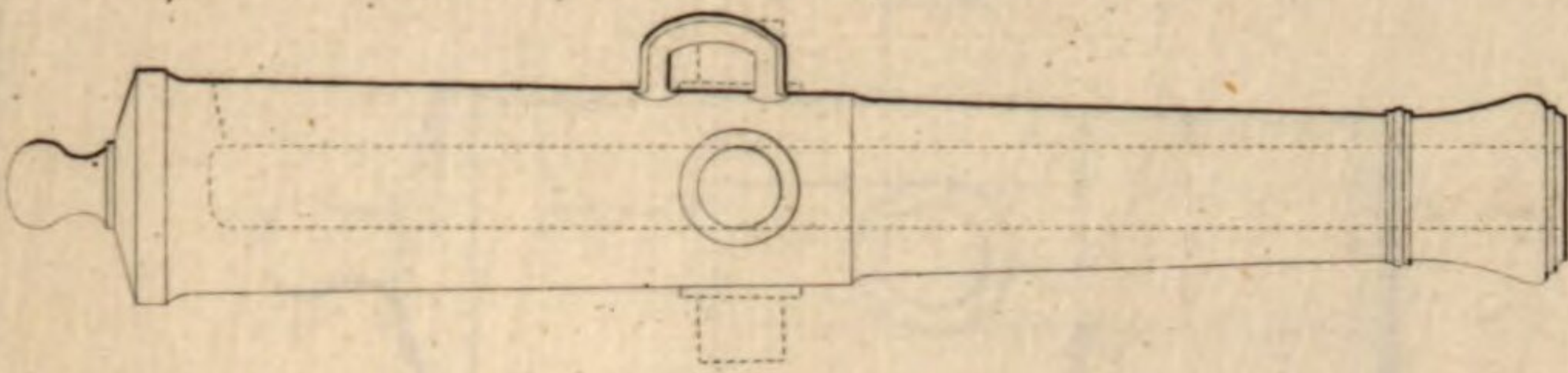
List of useful books of reference.

<i>Bélicor</i> , Bombardier Français	- - - - -	1731
<i>Saint Rémy</i> , Mémoires d'artillerie	- - - - -	1745
<i>Dupuget</i> , Essai sur l'usage de l'artillerie dans la guerre de campagne et celle de siège	- - - - -	1771
<i>Saint Auban</i> , Mémoires sur les nouveaux systèmes d'artillerie	- - - - -	1774
<i>Müller</i> , Treatise on Artillery	- - - - -	1780
<i>Jones</i> , Artificial Fire Works	- - - - -	1786
<i>Lombard</i> , Table de tir des Canons et Obusiers	- - - - -	1787
<i>Antoni</i> , On Gunpowder	- - - - -	1789
<i>Texier de Norbec</i> , Recherches sur l'artillerie en général	- - - - -	1792
<i>Monge</i> , Description de l'art de fabriquer les canons	- - - - -	1793
<i>Vandemonde</i> , Procédé sur la fabrication des armes blanches	- - - - -	1793
<i>Dürtubie</i> , Manuel de l'artilleur	- - - - -	1796
<i>Lombard</i> , Traité du mouvement des projectiles	- - - - -	1798
<i>Scheel</i> , Treatise on Artillery (Translated from the German)	- - - - -	1800
<i>Morel</i> , Traité pratique des feux d'artifice	- - - - -	1800
<i>Cornibert</i> , Manuel du canonnier marin	- - - - -	1800
<i>James</i> , Military Dictionary	- - - - -	1802
<i>Robins</i> , New principles of gunnery	- - - - -	1805
<i>Cotty</i> , Mémoires sur la fabrication des armes portatives	- - - - -	1806
<i>Cossigny</i> , Recherches sur la poudre	- - - - -	1807
— <i>Idem</i> —Supplément	- - - - -	1808
<i>Renaud</i> , Fabrication de la poudre	- - - - -	1808
<i>Toussard</i> , American Artillerist's Companion	- - - - -	1809
<i>Cornibert</i> , Tables des portées des canons et carronades de la marine	- - - - -	1809
<i>Bigot</i> , Traité d'artifices de guerre	- - - - -	1809
<i>Dartein</i> , Traité élémentaire de la fabrication des bouches à feu	- - - - -	1810
<i>Bottée et Riffault</i> , Traité de l'art de fabriquer la poudre à canon	- - - - -	1811
<i>Bottée et Riffault</i> , L'art du Salpétrier	- - - - -	1812
<i>Hoyer</i> , Dictionary of Artillery (German)	- - - - -	1812
<i>Hutton</i> , New experiments in gunnery, (Hutton's Tracts)	- - - - -	1812
<i>Herbin de Halles</i> , Des bois propres au service des Arsenaux	- - - - -	1813
<i>Hulot</i> , Instruction sur le service de l'artillerie	- - - - -	1813
<i>Duane</i> , Military Dictionary	- - - - -	1813
<i>Bigot</i> , Manœuvres de force	- - - - -	1814
<i>D'Obenheim</i> , Balistique	- - - - -	1814
<i>Scharnhorst</i> , Treatise on Artillery, German [translated into French, 1840]	- - - - -	1814
<i>Poumet</i> , Essai sur l'art de pointer	- - - - -	1816
<i>Douglass</i> , Essay on Military Bridges	- - - - -	1816
<i>Lamartillière</i> , Réflexions sur la fabrication des bouches à feu	- - - - -	1817
<i>D'Obenheim</i> , Mémoire sur la planchette du canonnier	- - - - -	1818
<i>Gassendi</i> , Aide Mémoire	- - - - -	1819
Observations on the use of Artillery, at the sieges of Badajos, St. Sebastian, &c.	- - - - -	1819
<i>Drieu</i> , Guide du pontonnier, et Mémoire sur les ponts	- - - - -	1820
<i>Dupin</i> , Force Militaire de la Grande Bretagne	- - - - -	1820
<i>Lallemand</i> , Treatise on Artillery	- - - - -	1820
<i>Ruggieri</i> , Elémens de Pyrotechnie	- - - - -	1821

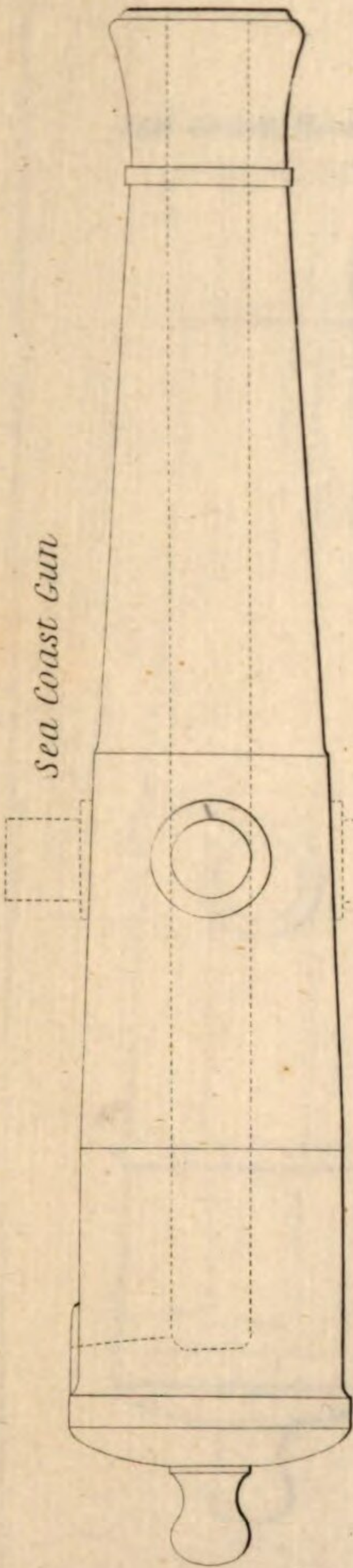
<i>Paixhans</i> , Nouvelle force maritime	-	-	-	-	1822
<i>Cotty</i> , Dictionnaire d'artillerie	-	-	-	-	1822
<i>Coste</i> , Recherches balistiques	-	-	-	-	1823
<i>Vergnaud</i> , Poudres fulminantes	-	-	-	-	1824
<i>Culman</i> , Manuel de la métallurgie du fer	-	-	-	-	1824
Pyrotechnie Militaire, traduit de l'Allemand par R. de Peretsdorff	-	-	-	-	1824
Journal des Sciences Militaires ; commencé en	-	-	-	-	1825
<i>Cutbush</i> , Pyrotechny	-	-	-	-	1825
<i>Decker</i> , Traité élémentaire d'artillerie	-	-	-	-	1825
<i>Montgéry</i> , Fusées de guerre	-	-	-	-	1826
<i>Hervé</i> , Documens sur la matière à canons	-	-	-	-	1827
<i>Allix</i> , Observations sur le nouveau système d'artillerie	-	-	-	-	1827
<i>Allix</i> , Système d'artillerie de campagne	-	-	-	-	1827
<i>Adye</i> , Pocket Gunner	-	-	-	-	1827
<i>Congreve</i> , On the Rocket system	-	-	-	-	1827
<i>Serres</i> , Essai sur l'art des fontes	-	-	-	-	1827
<i>Proust</i> , Recueil de Mémoires sur la poudre à canon	-	-	-	-	1827-'8
<i>Michel</i> , Mémorial de l'artilleur marin	-	-	-	-	1828
<i>Poumet</i> , Observations sur le nouveau système d'artillerie	-	-	-	-	1828
Memorial de l'artillerie, 4 parties	-	-	-	-	1827, '28, '30, '37
<i>Spearman</i> , British Gunner	-	-	-	-	1828
<i>Montgéry</i> , Régles de pointage à bord des vaisseaux	-	-	-	-	1828
<i>Landrin</i> , Manuel du maître de forges	-	-	-	-	1829
<i>Douglass</i> , Naval Gunnery	-	-	-	-	1829
<i>Karsten</i> , Métallurgie du fer, traduit de L'Allemand par Culman	-	-	-	-	1830
Aide Mémoire, à l'usage des officiers d'artillerie (Strasbourg)	-	-	-	-	1831
<i>Grewenitz</i> , Traité de l'organisation et de la tactique de l'artillerie, traduit de l'Allemand par Peretsdorff	-	-	-	-	1831
<i>Cotty</i> , Supplément au dictionnaire d'artillerie	-	-	-	-	1832
<i>Braddock</i> , Memoir on Gunpowder	-	-	-	-	1832
<i>Paulin-Desormeaux</i> , Manuel de l'armurier	-	-	-	-	1832
Journal des Armes Spéciales	-	-	-	-	1834
<i>Serres</i> , Cours sur le service des officiers dans les fonderies	-	-	-	-	1834
<i>Meyer</i> , Expériences sur la fabrication et la durée des bouches à feu en fer et en bronze, traduit de l'Allemand par Peretsdorff	-	-	-	-	1834
<i>Thiéry</i> , Applications du fer aux constructions de l'artillerie	-	-	-	-	1834
<i>Lebas</i> , Aide Mémoire d'art militaire	-	-	-	-	1834
Mémorial à l'usage de l'armée Belge	-	-	-	-	1835
Instructions and Regulations for the service and management of heavy ordnance in the British service	-	-	-	-	1835
Expériences sur les principes du tir, faites à Metz en 1834	-	-	-	-	1836
<i>Piobert</i> , Traité d'artillerie théorique et pratique ; Partie élémentaire	-	-	-	-	1836
Aide Mémoire à l'usage des officiers d'artillerie, (avec approbation du Comité d'artillerie) Paris	-	-	-	-	1836
<i>Bonaparte</i> , (<i>Napoleon Louis</i> ,) Manuel d'artillerie à l'usage des officiers de la République Helvétique	-	-	-	-	1836
<i>Le Bourg</i> , Essai sur l'organisation de l'artillerie, 2 parties	-	-	-	-	1836-'7
Expériences comparatives entre des bouches à feu en fonte de fer, d'origine Française, Anglaise et Suédoise, faites à Gâvres en 1836	-	-	-	-	1837
Expériences faites à Brest en 1831 sur les canons Paixhans	-	-	-	-	1837

- Expériences sur des projectiles creux, faites en 1829, '30, '31 - - 1837
- Decker*, Instruction pratique sur l'emploi des projectiles, traduit de l'Allemand par Peretsdorff - - - 1837
- Simmons*, Effects of heavy ordnance as applied to ships of war - 1837
- Maguin*, Expériences sur les poudres de guerre, faites à Esquerdes en 1832, '33, '34, and '35 - - - 1837
- De Crépy*, Cours d'artillerie à l'usage des sous-officiers - - 1837
- Thiroux*, Instruction théorique et pratique d'artillerie, à l'usage des élèves de St. Cyr - - - 1837
- Cours sur le service des officiers d'artillerie dans les forges - - 1837
- Meyer*, Manuel Historique de la technologie des armes à feu; traduit de l'Allemand par M. Rieffel, 2 parties - - 1837-'38
- Poisson*, Formules relatives aux effets du tir sur l'affût - - 1838
- Morin*, Aide Mémoire de mécanique pratique - - - 1838
- Vergnaud*, Manuel de l'artificier - - - 1838
- Jacobi*, Etat Actuel de l'artillerie de campagne de toutes les puissances de l'Europe; traduit par Mazé: 1re partie, Artillerie Anglaise - 1838
(Six other parts have been published in German, containing descriptions of the French, Belgian, Hessian, Wirtemberg, Nassau, and Swedish systems.)
- Madelaine*, Introduction à l'étude de l'artillerie.
- Cours sur le service des officiers d'artillerie dans les fonderies - 1839
- Huguenin*, Description de la fabrication des bouches à feu à la fonderie royale de Liège - - - 1839
- Timmerhans*, Poudre à Canon - - - 1839
- Procédés de fabrication dans les forges, (extrait du cours sur le service des officiers dans les forges) - - - 1839
- Zeni et Des Hays*, Renseignements sur le matériel de l'artillerie navale de la Grande Bretagne - - - 1840
- Migout et Bergery*, Théorie des affûts et des voitures de l'artillerie - 1840
- Griffith*, Artillerist's Manual - - - 1840
- Handbuch für die K. K. Oesterreichische artillerie-offiziere, [Manual for the Austrian artillery officers] - - - 1840
- Saamlung von steindruckzeichnungen der Preussischen artillerie, mit erläuterungen—[Collection of plates of the Prussian artillery, with explanatory text] - - - 1837 to 1840
- Corréard*, Histoire des fusées de guerre—Tome 1er. - - - 1841

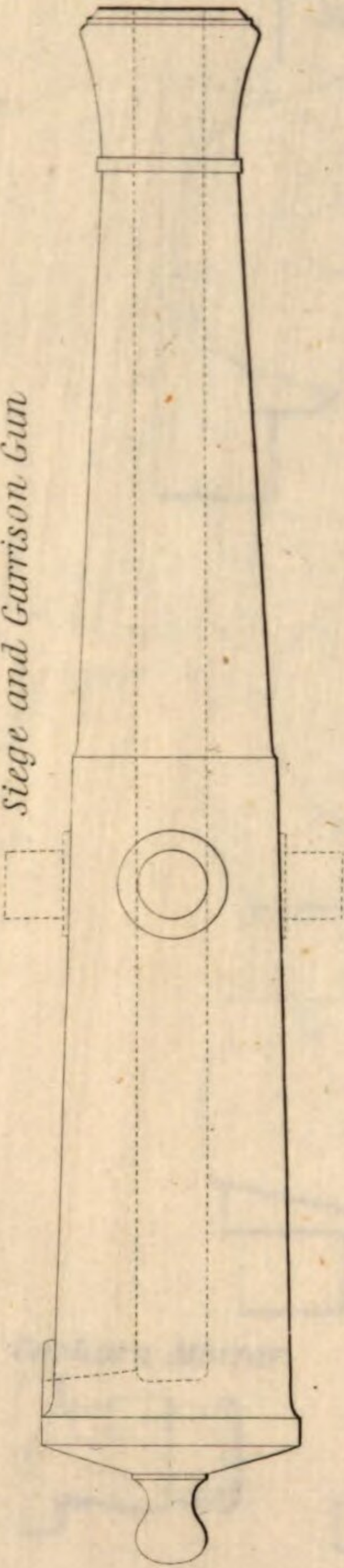
Field Gun



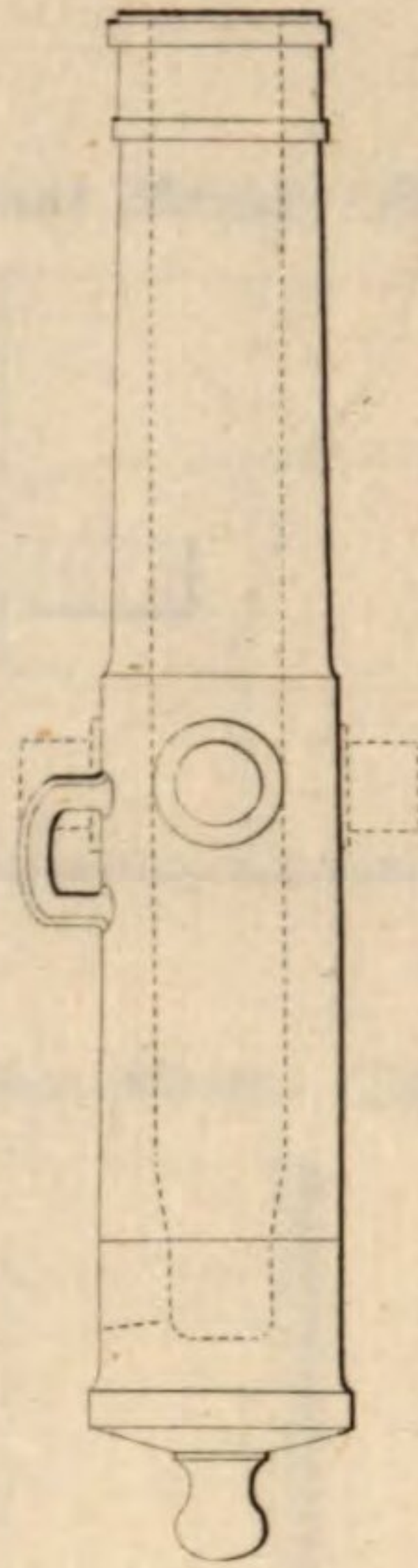
Sea Coast Gun



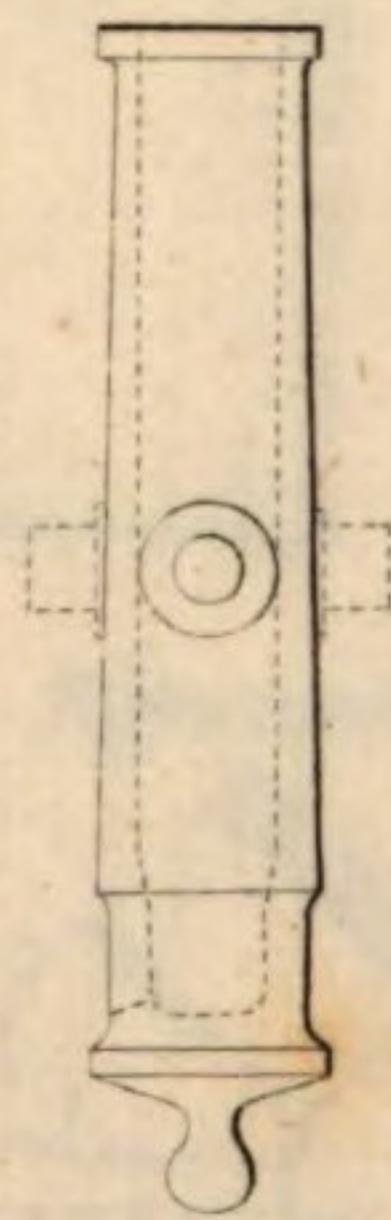
Siege and Garrison Gun

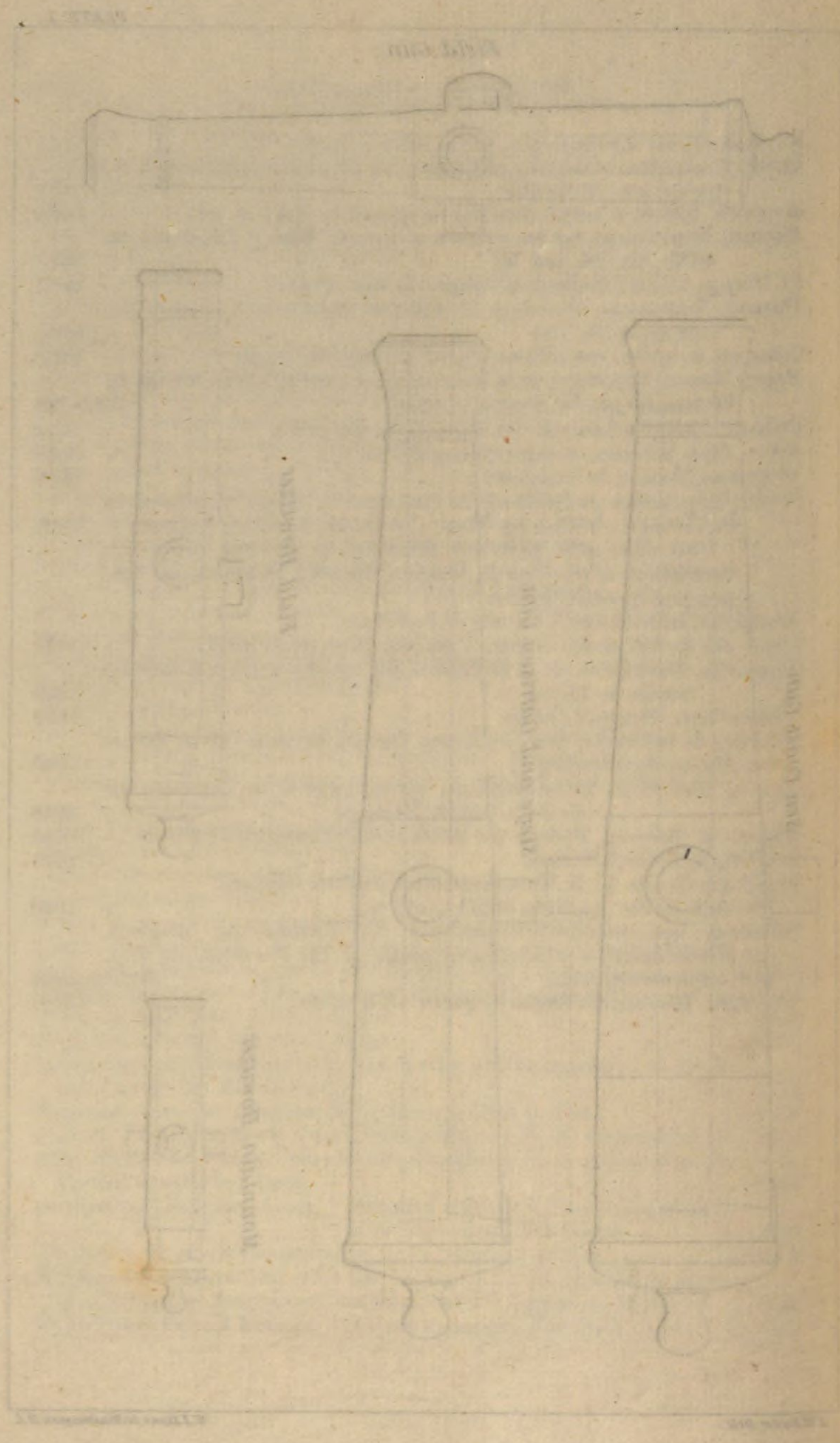


Field Howitzer

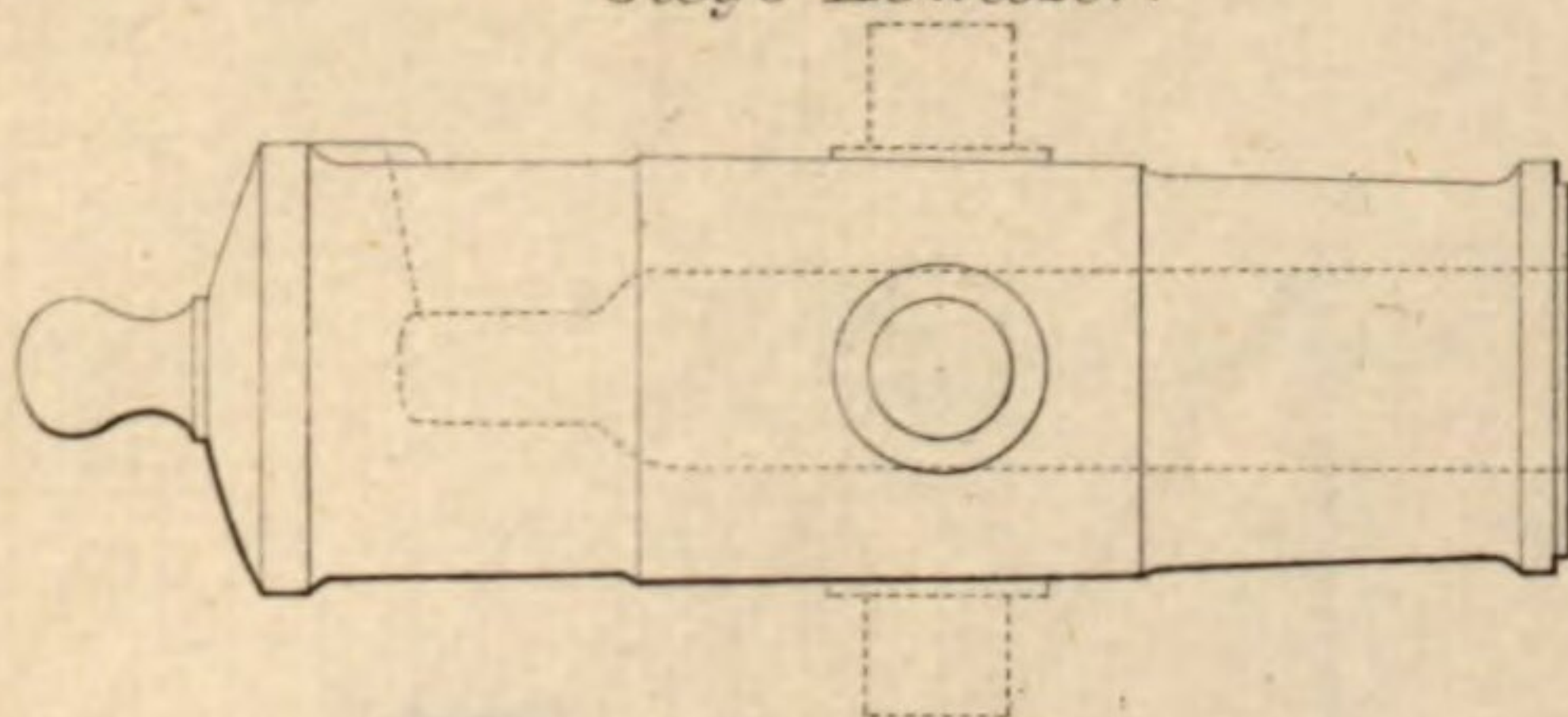


Mountain Howitzer

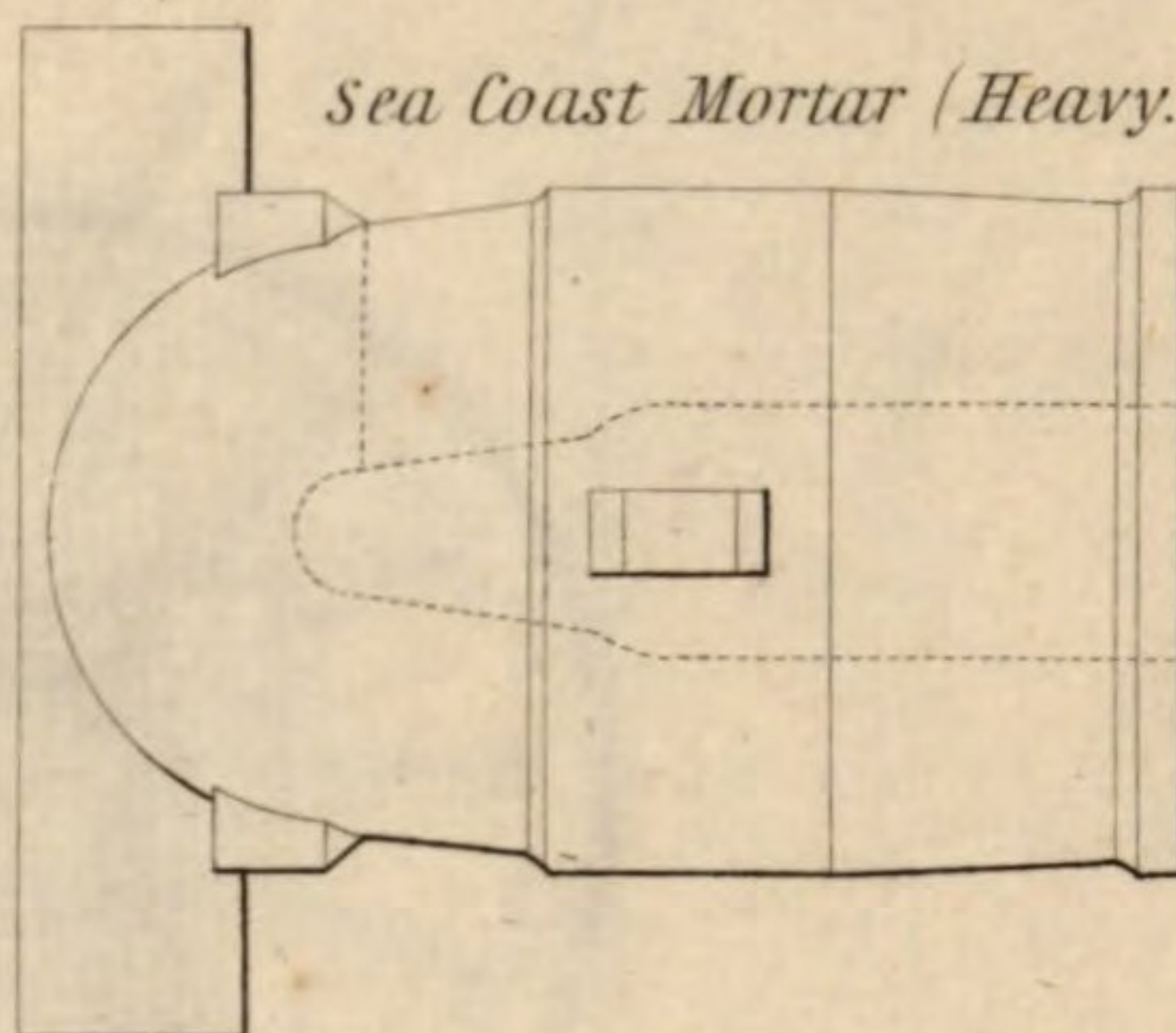




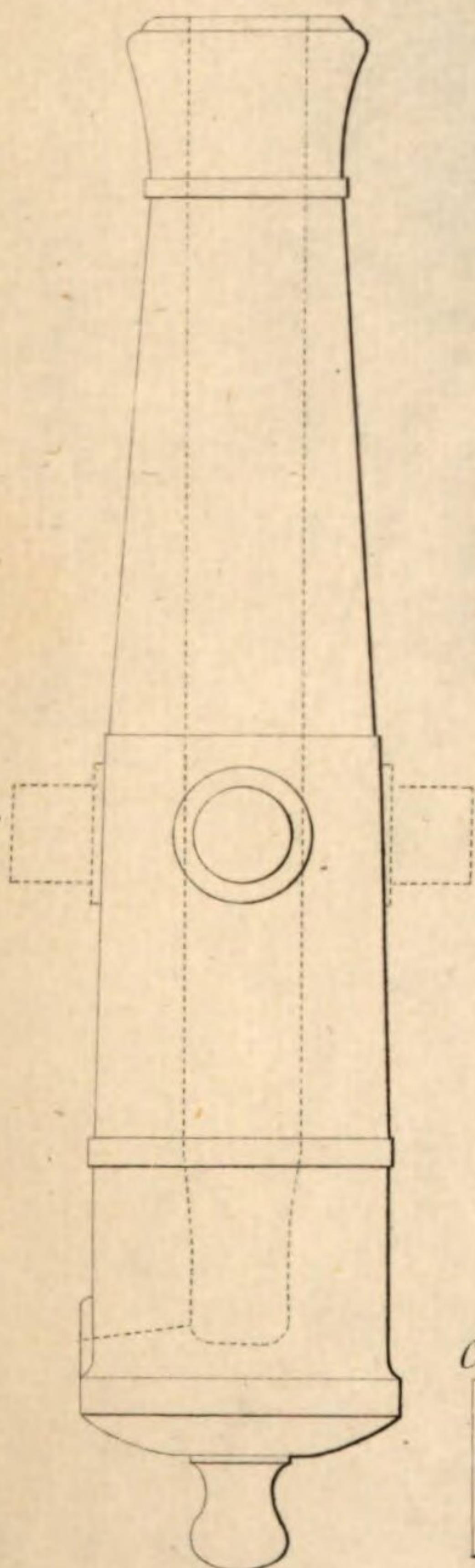
Siege Howitzer.



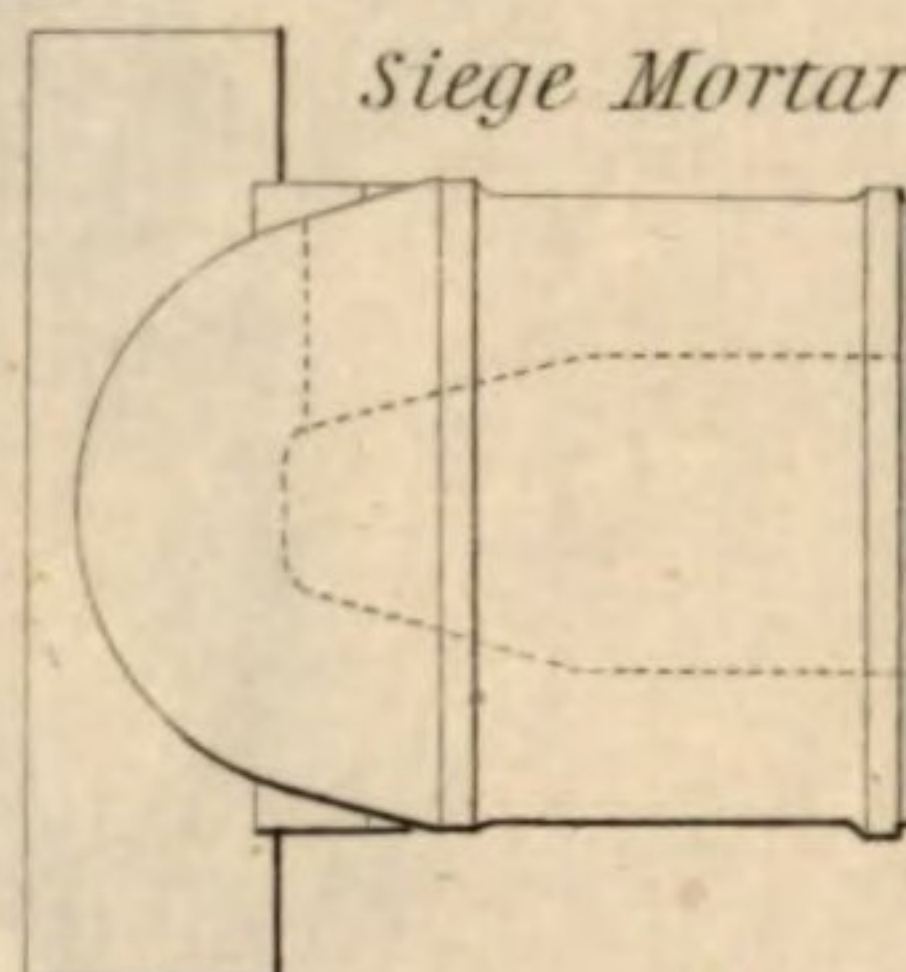
Sea Coast Mortar (Heavy.)



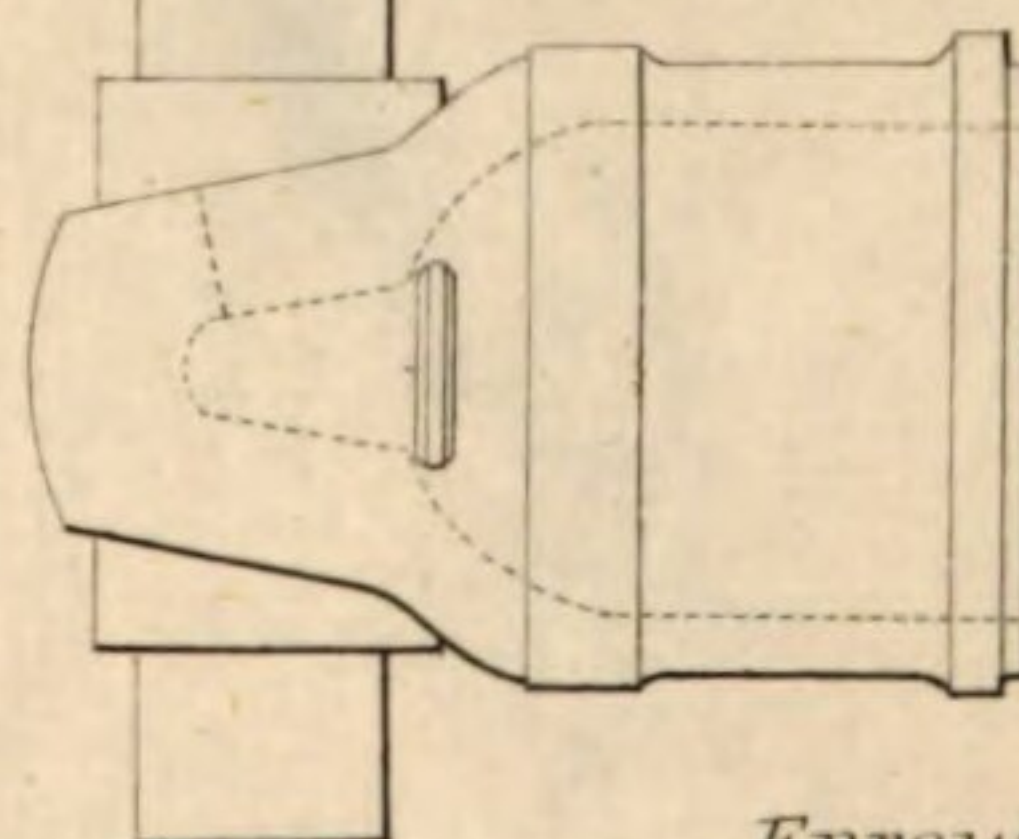
Sea Coast Howitzer.



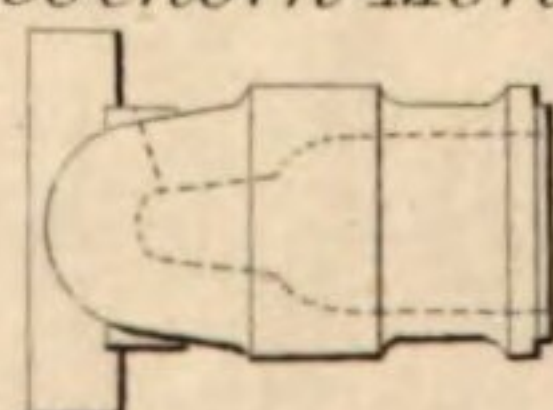
Siege Mortar (Light.)



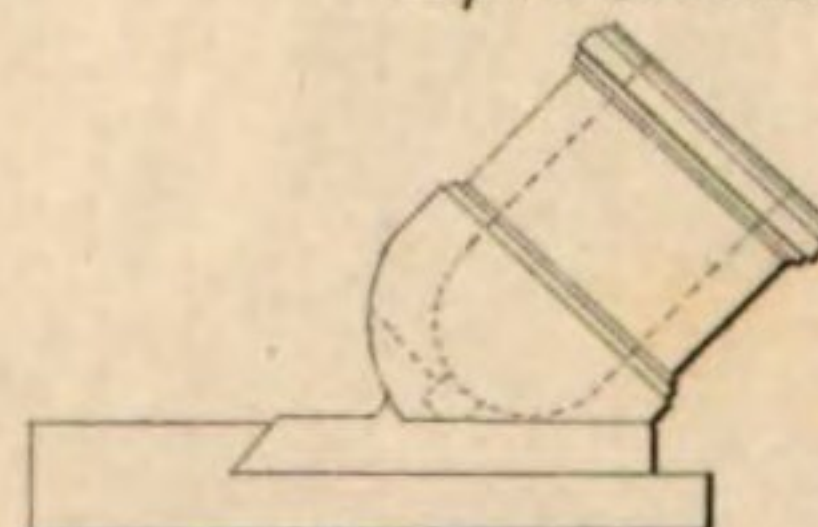
Stone Mortar.

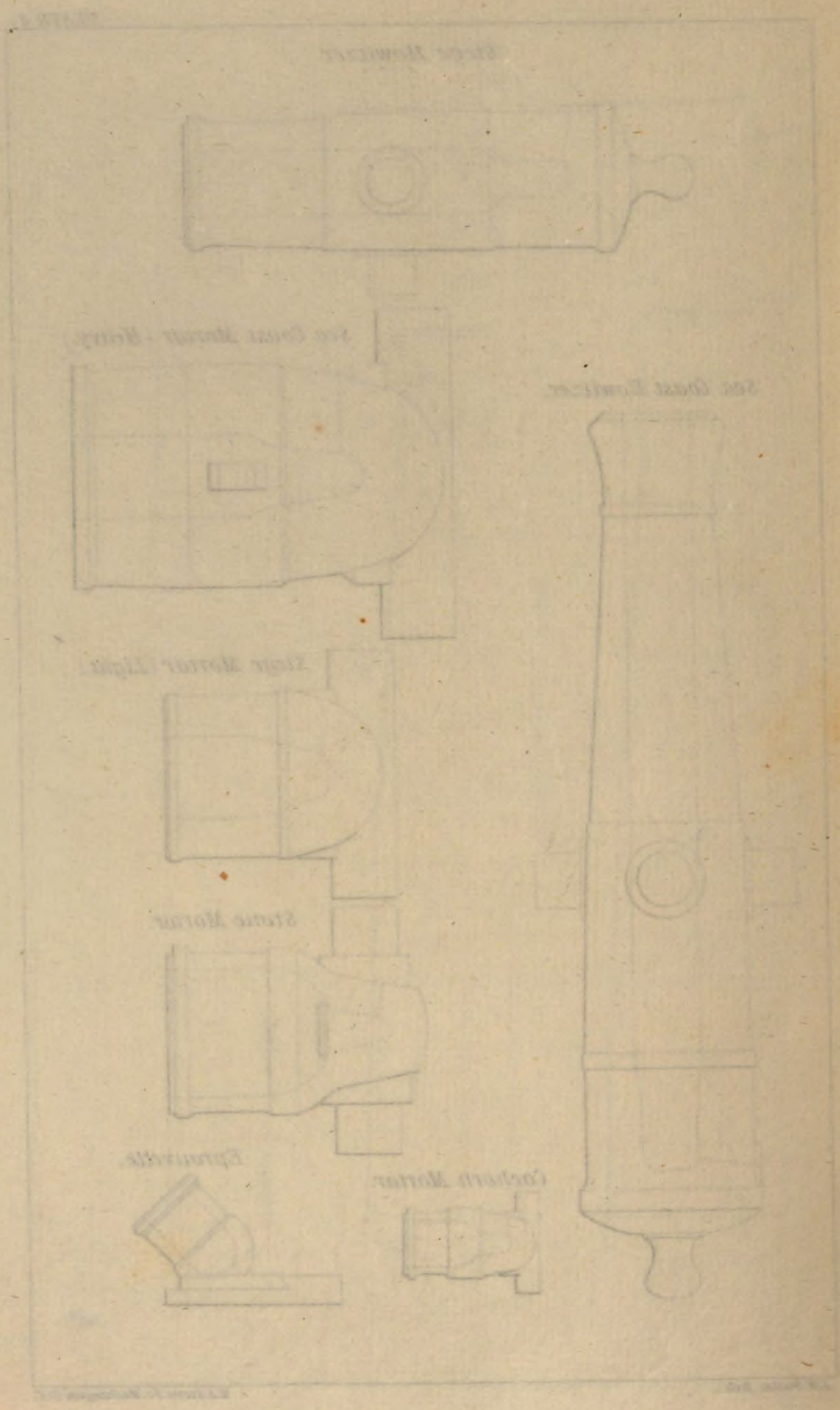


Coehorn Mortar.

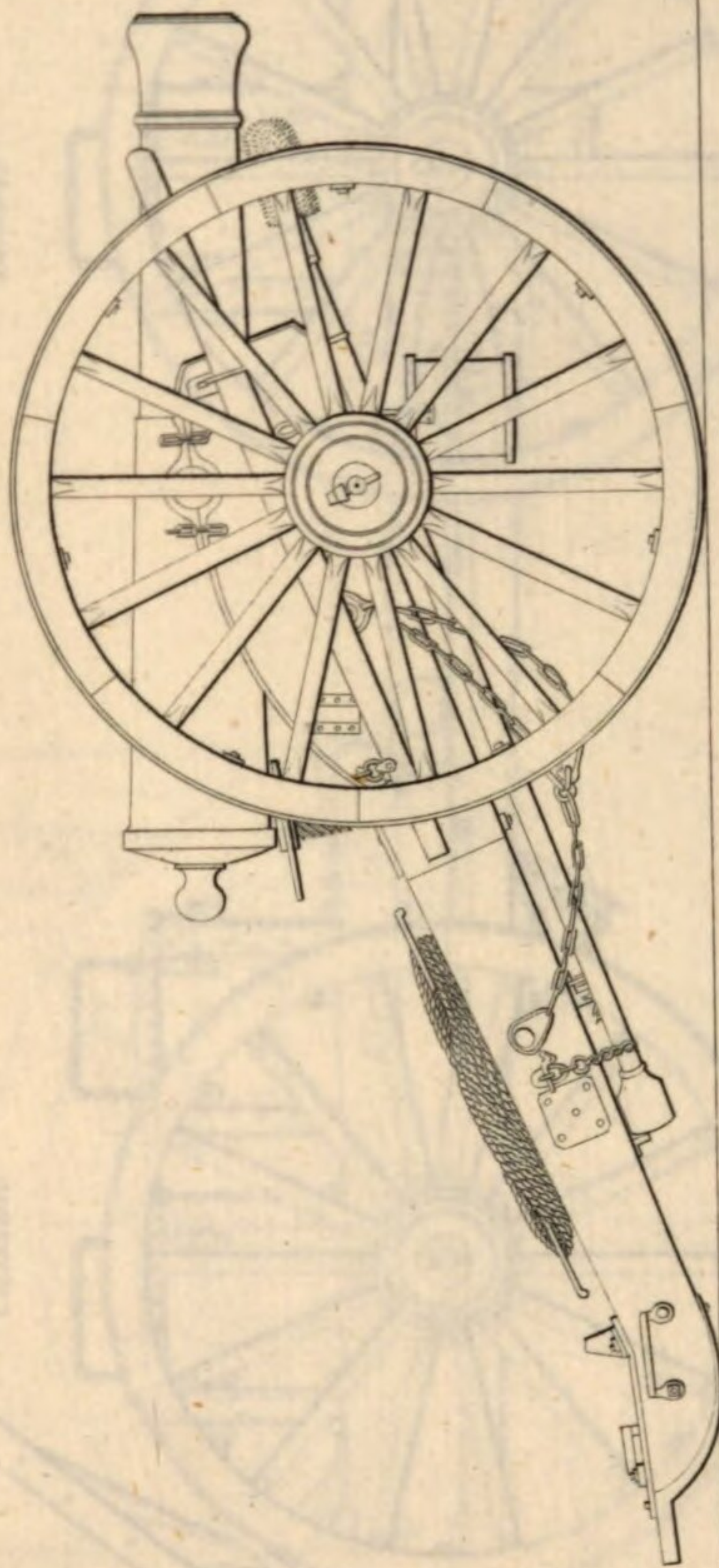


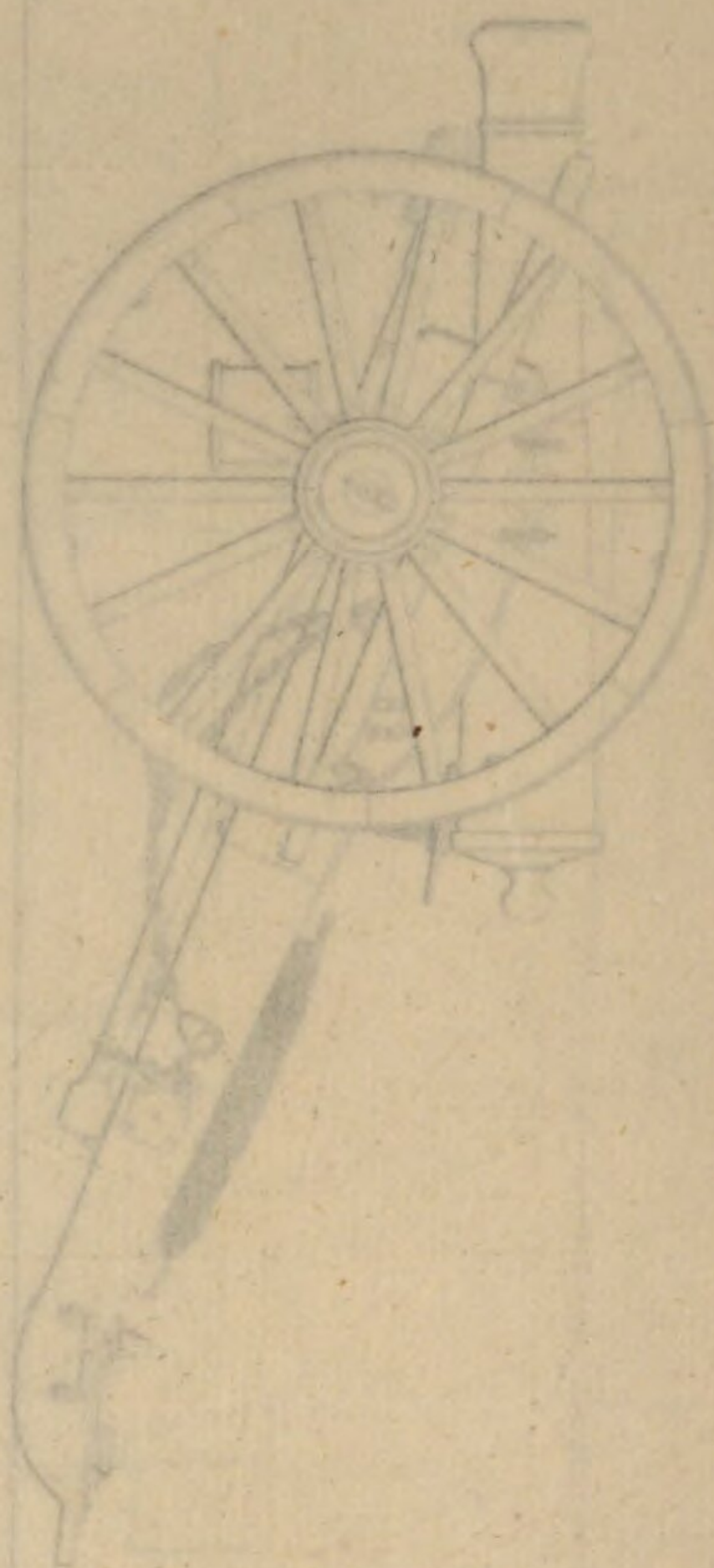
Eprouvette.



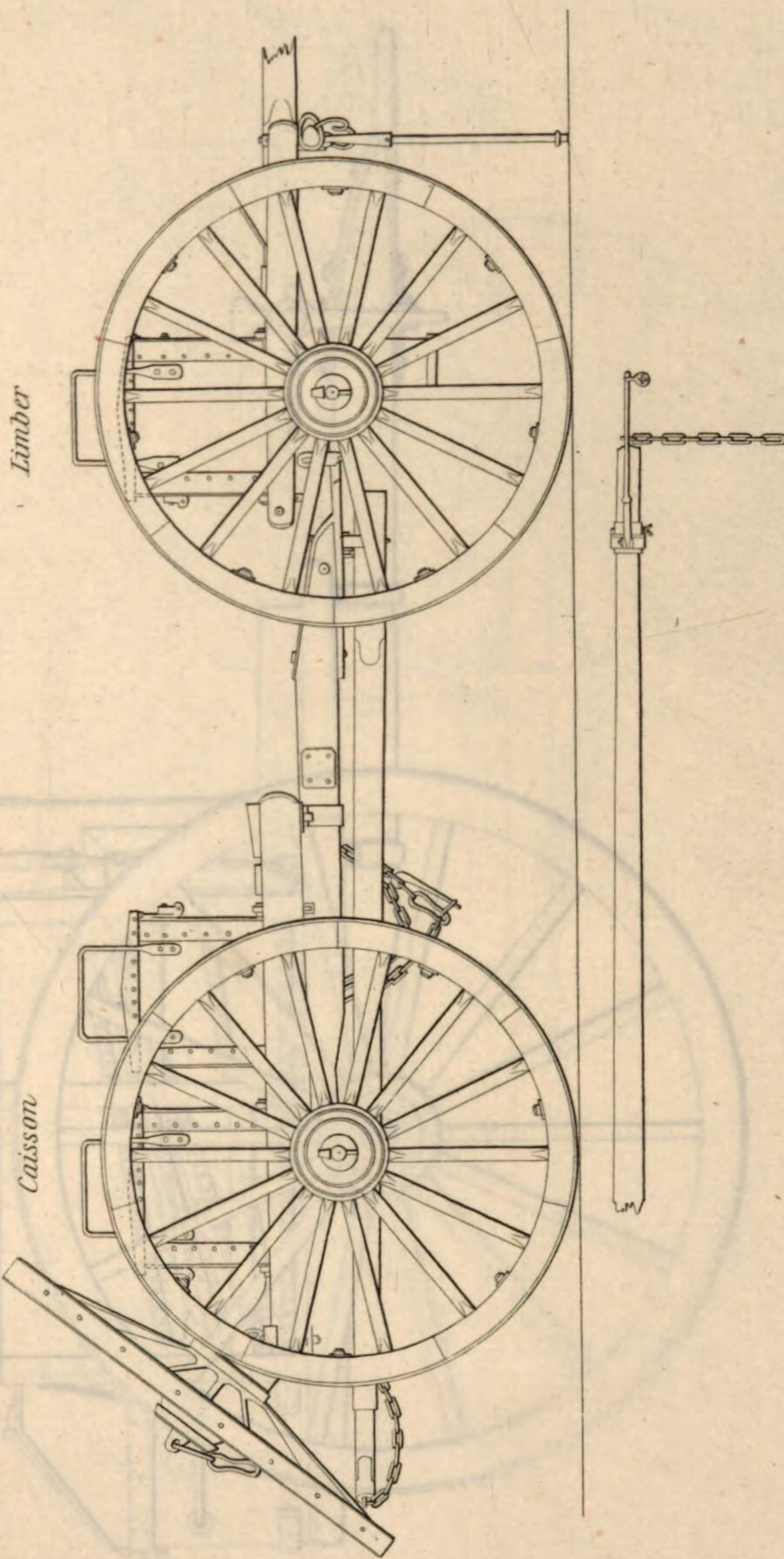


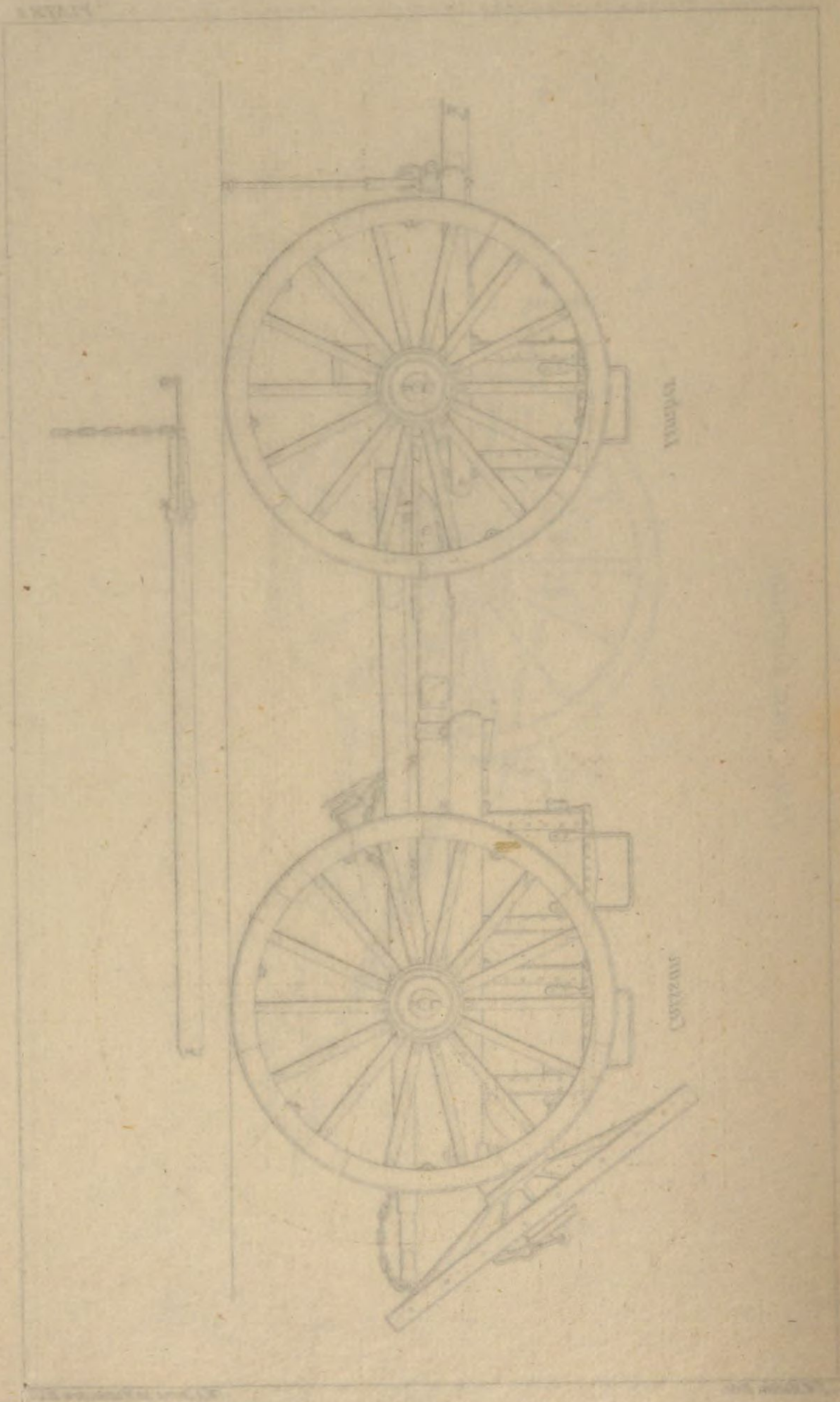
Field Gun Carriage





LOCOMOTIVE AND RAIL

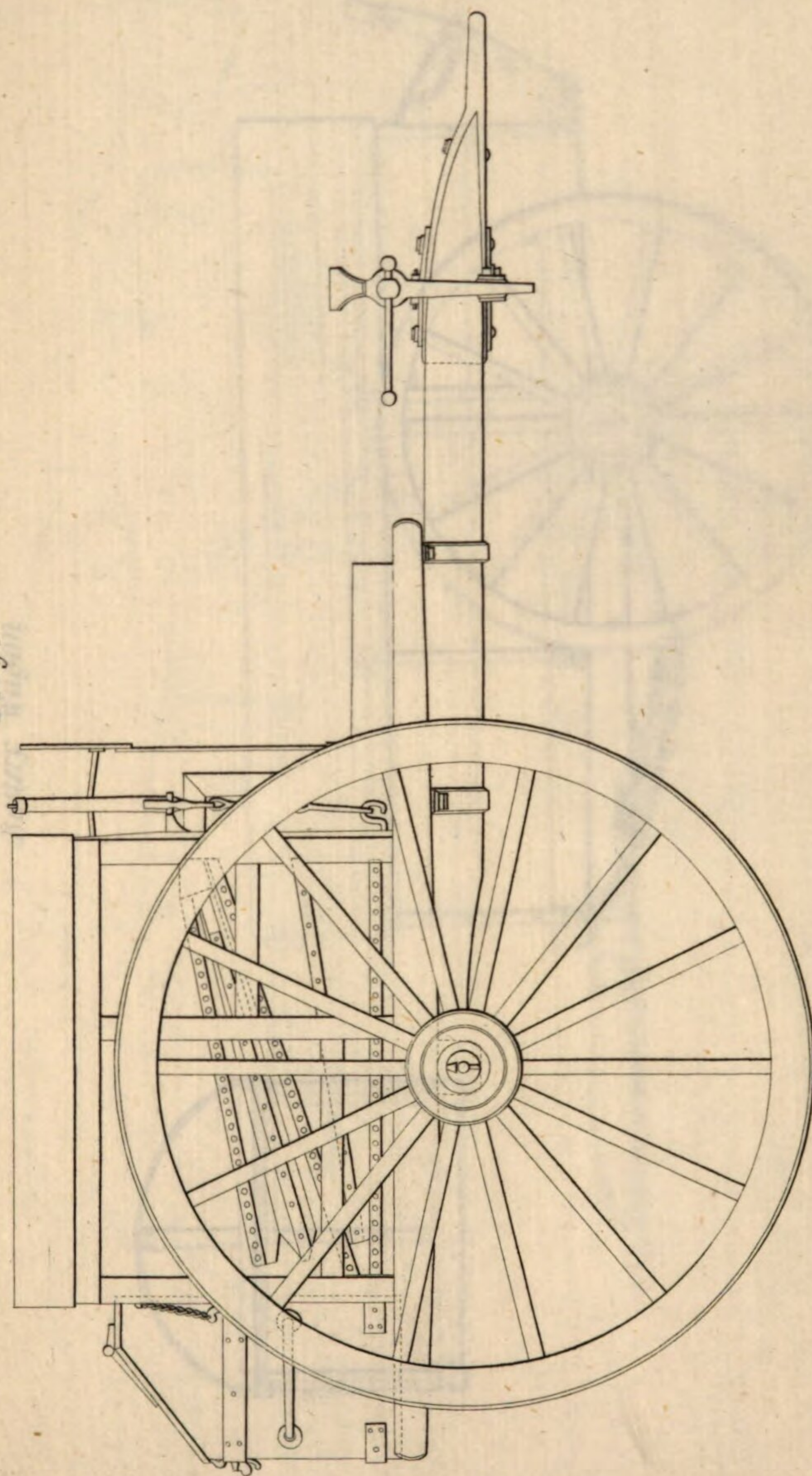




WHEEL

WHEEL

Forge



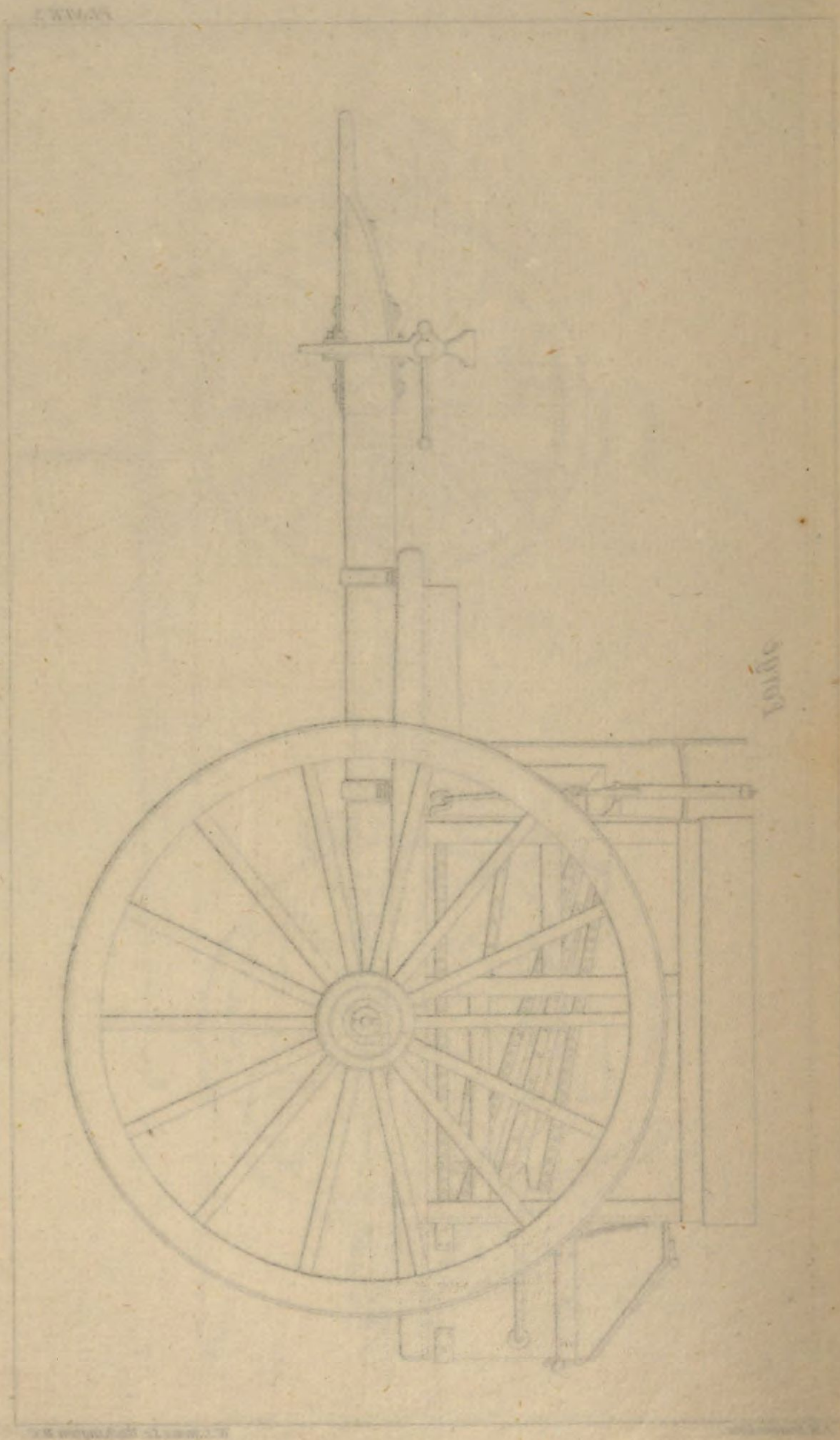
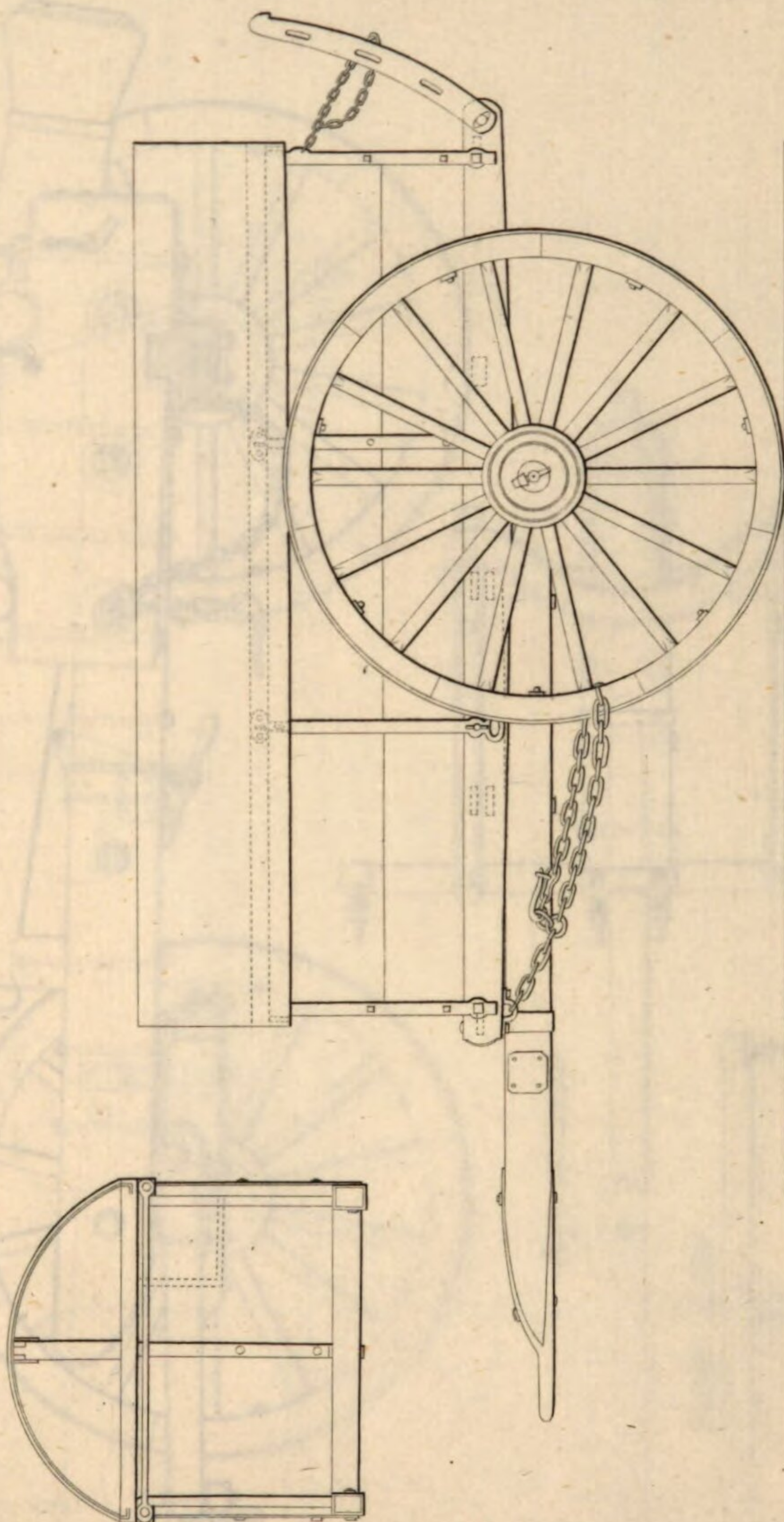
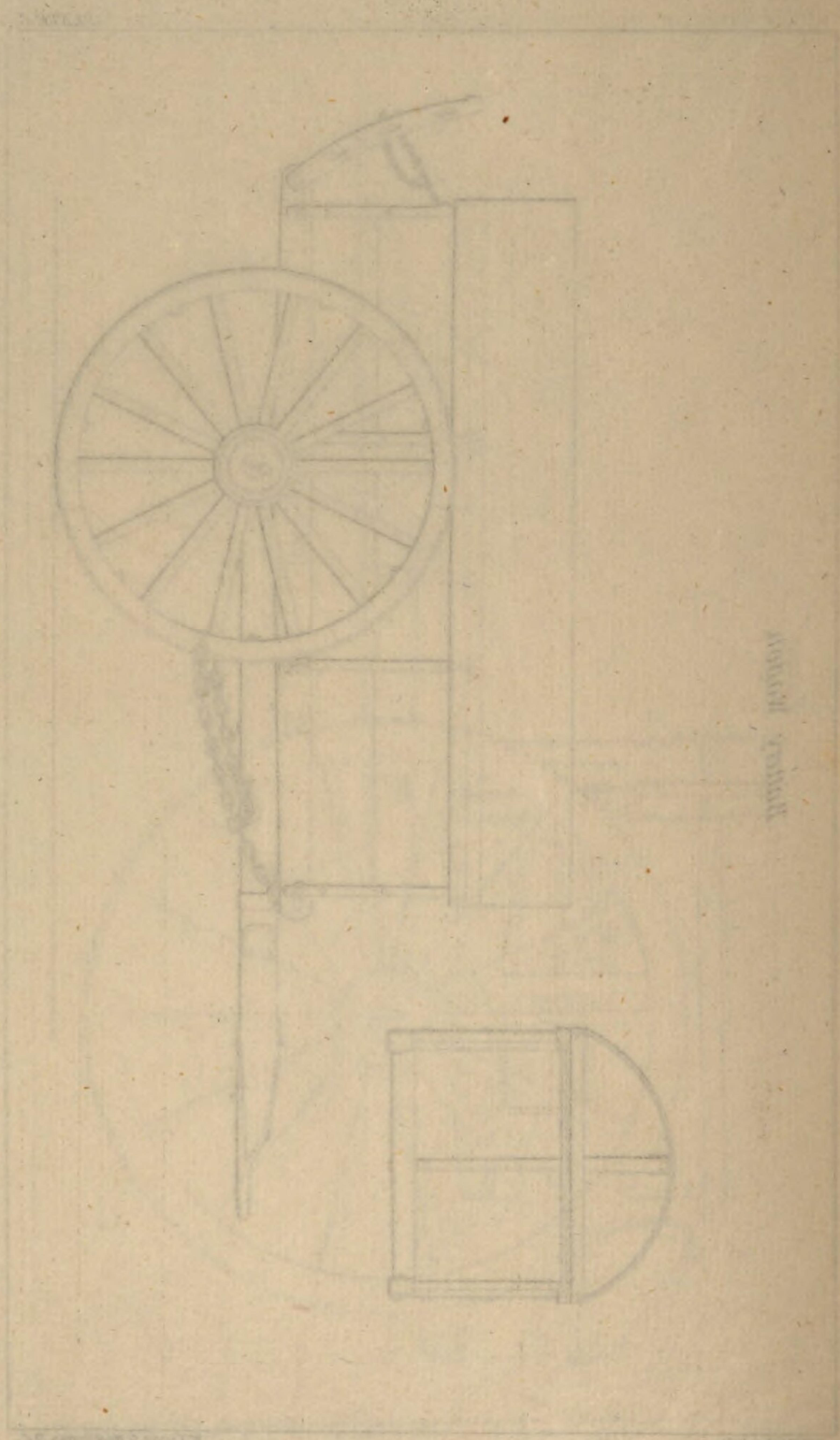


Fig. 1

Battery Wagon

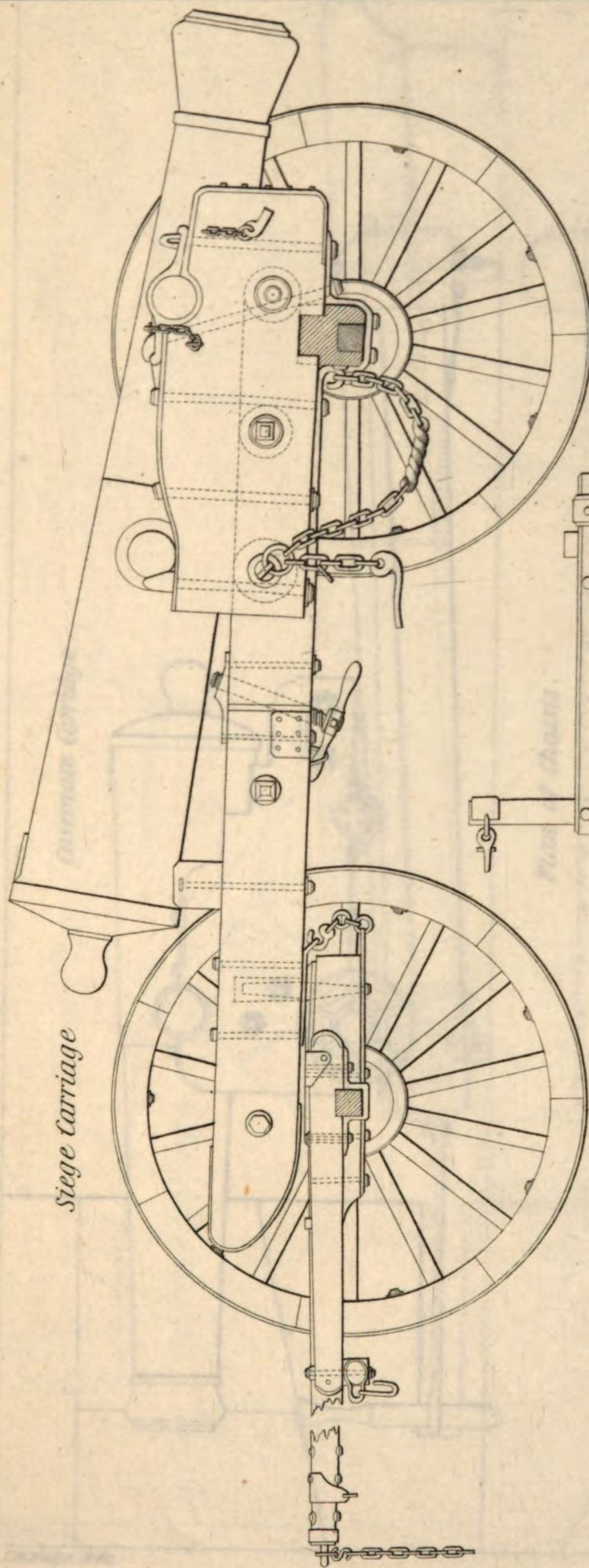




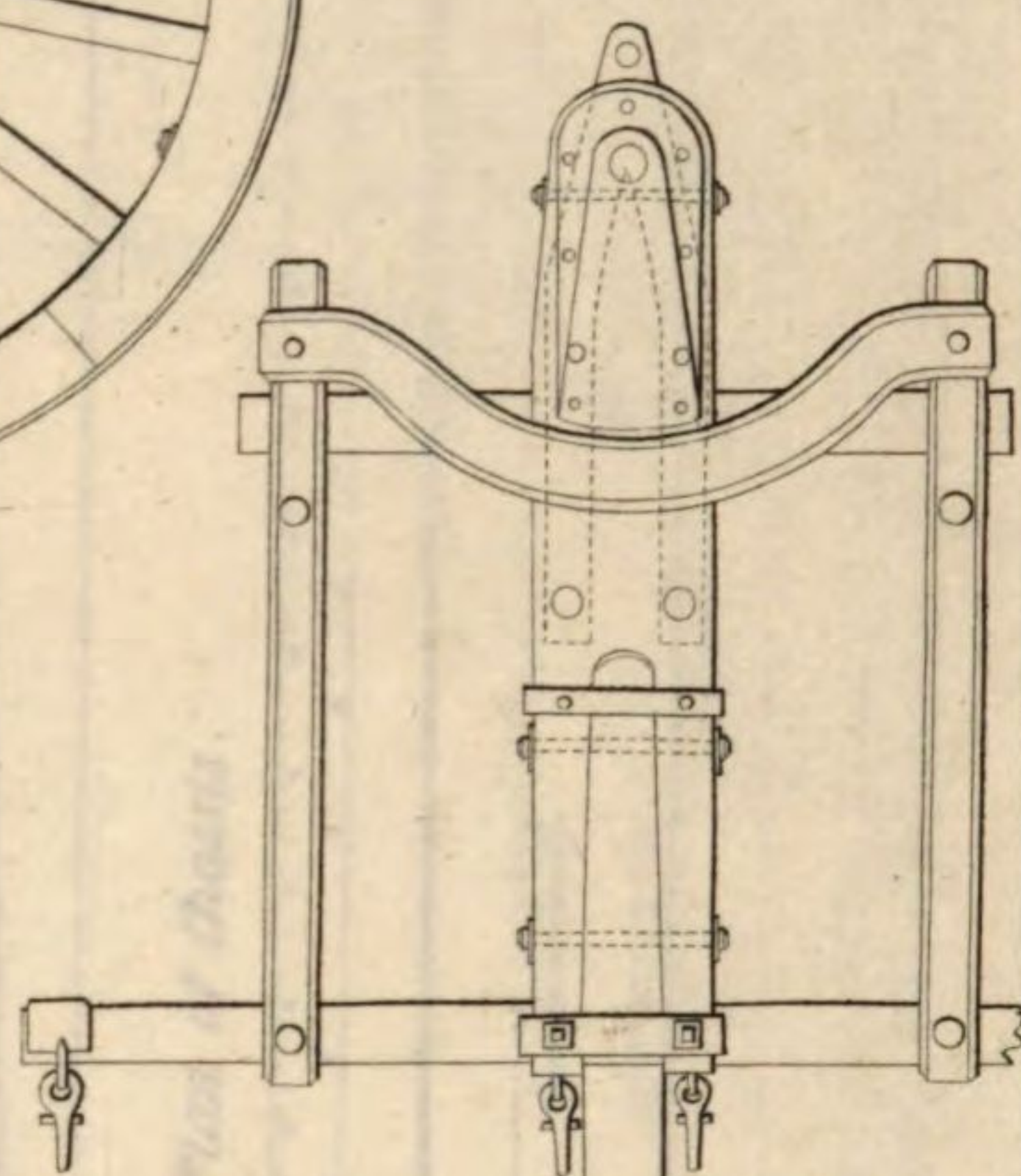
Vertical Pump

Vertical Pump

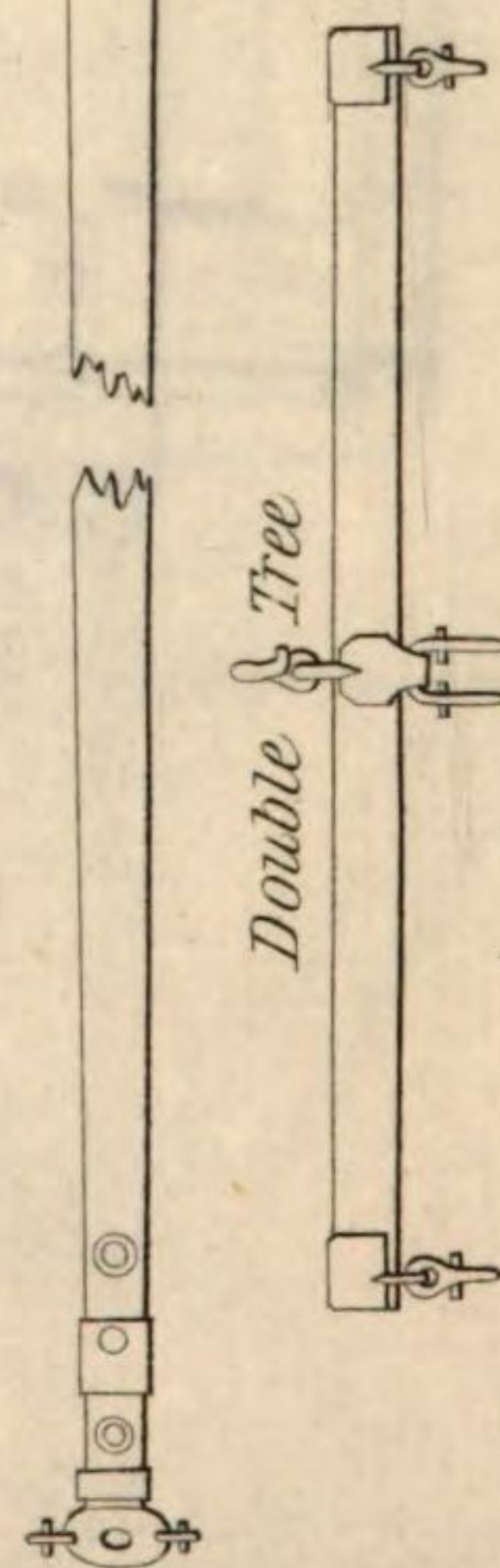
Vertical Pump



Siege Carriage



Plan of Limber



Double Tree

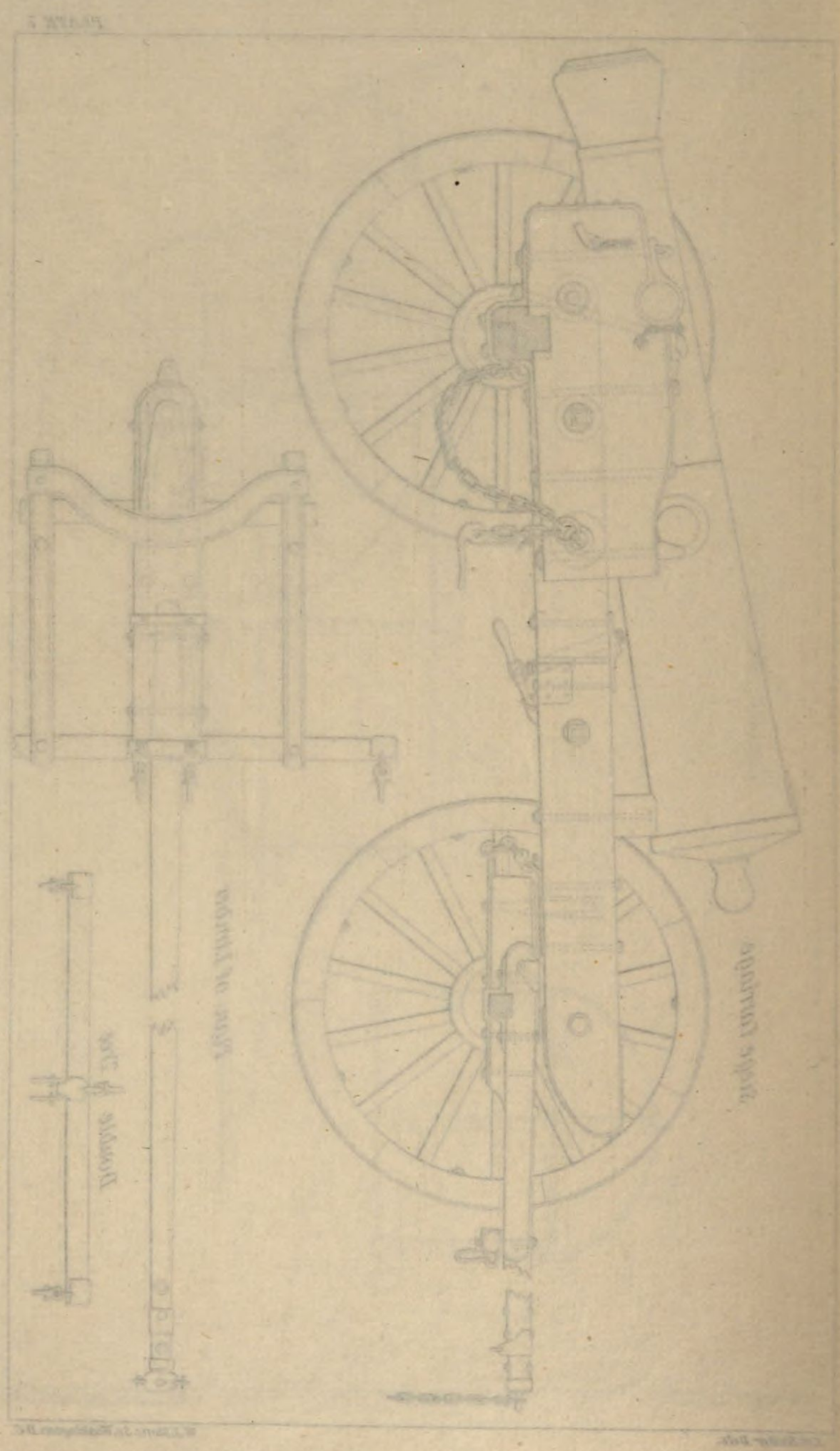


Fig. 1

Side Elevation

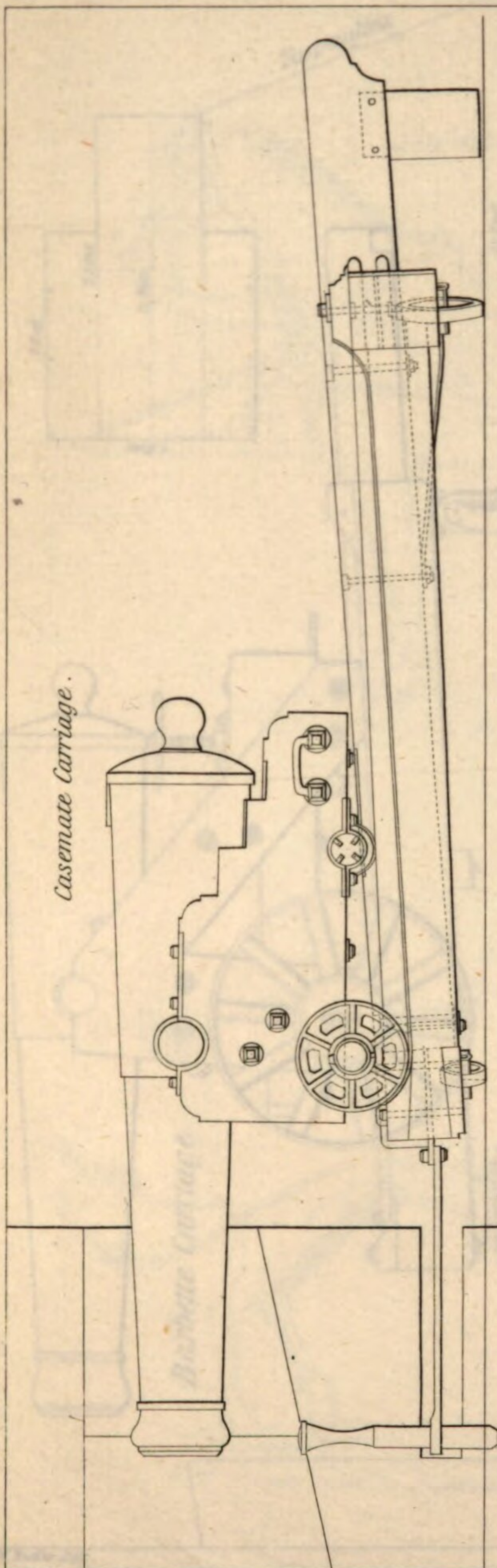
Plan View

Fig. 2

W. & A. G. & Co. Engineers, London

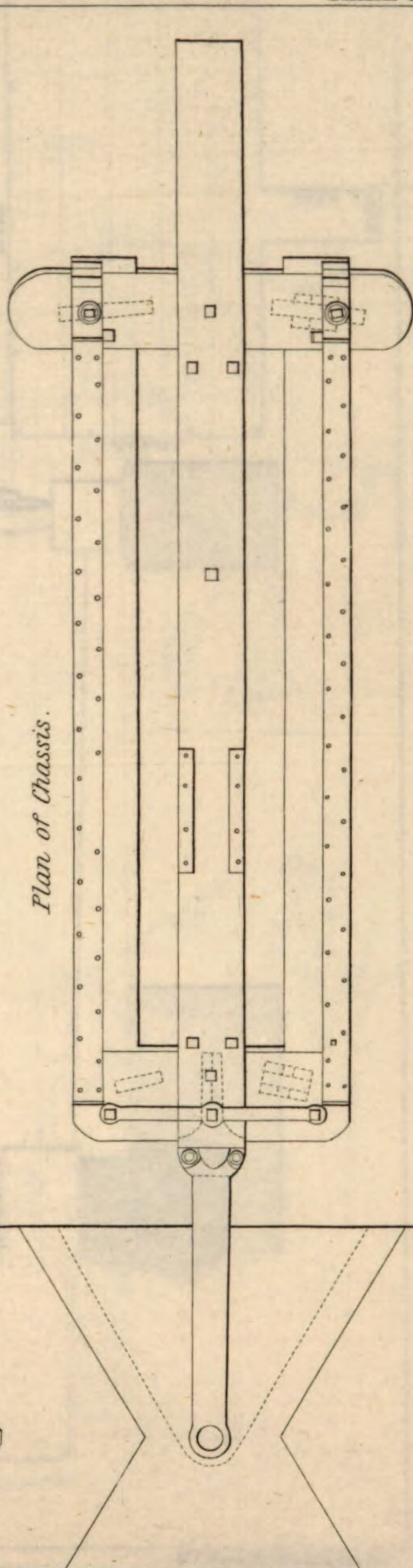
Copyright 1864

Casemate Carriage.

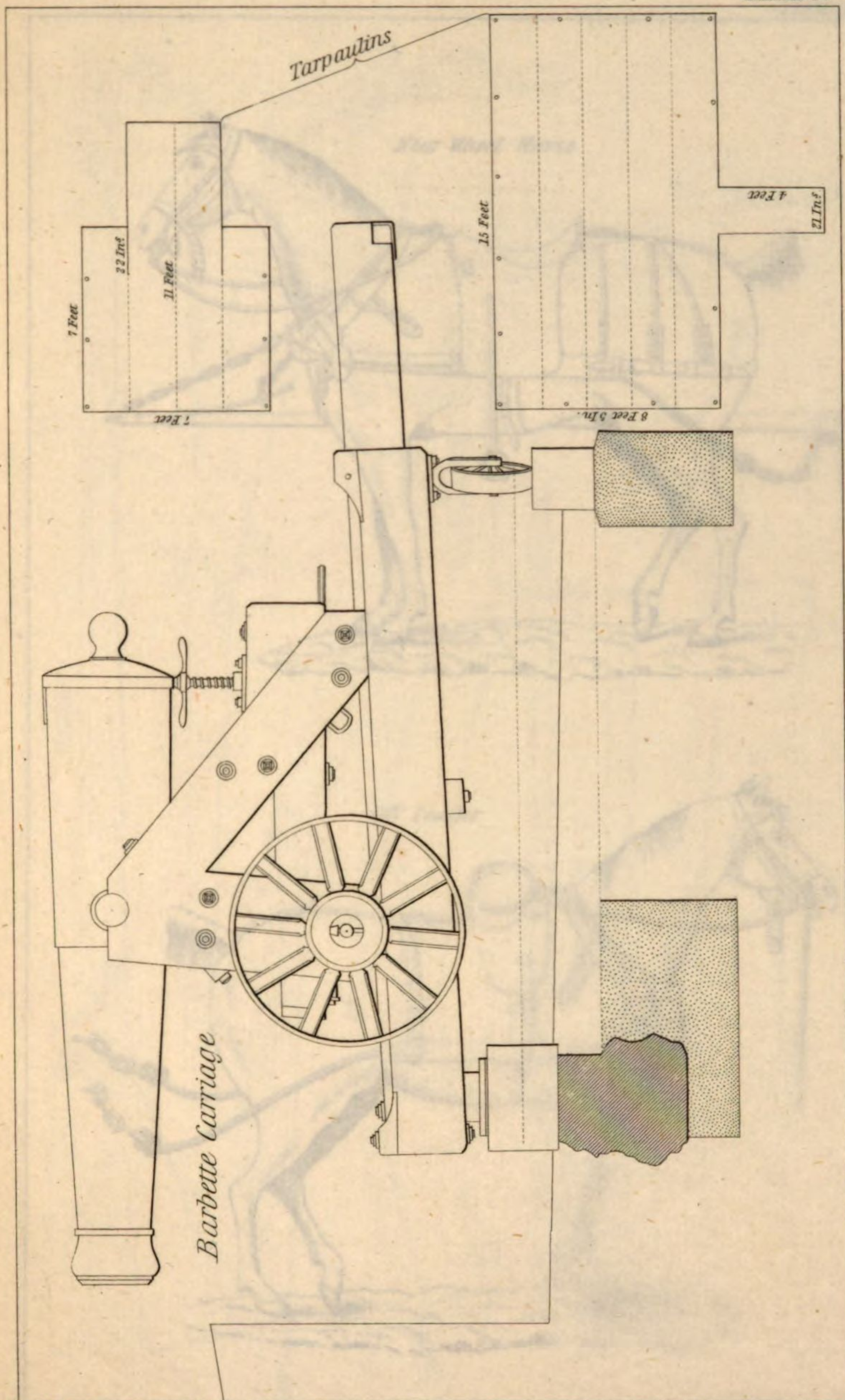


J.W. Butler Del.

Plan of Chassis.

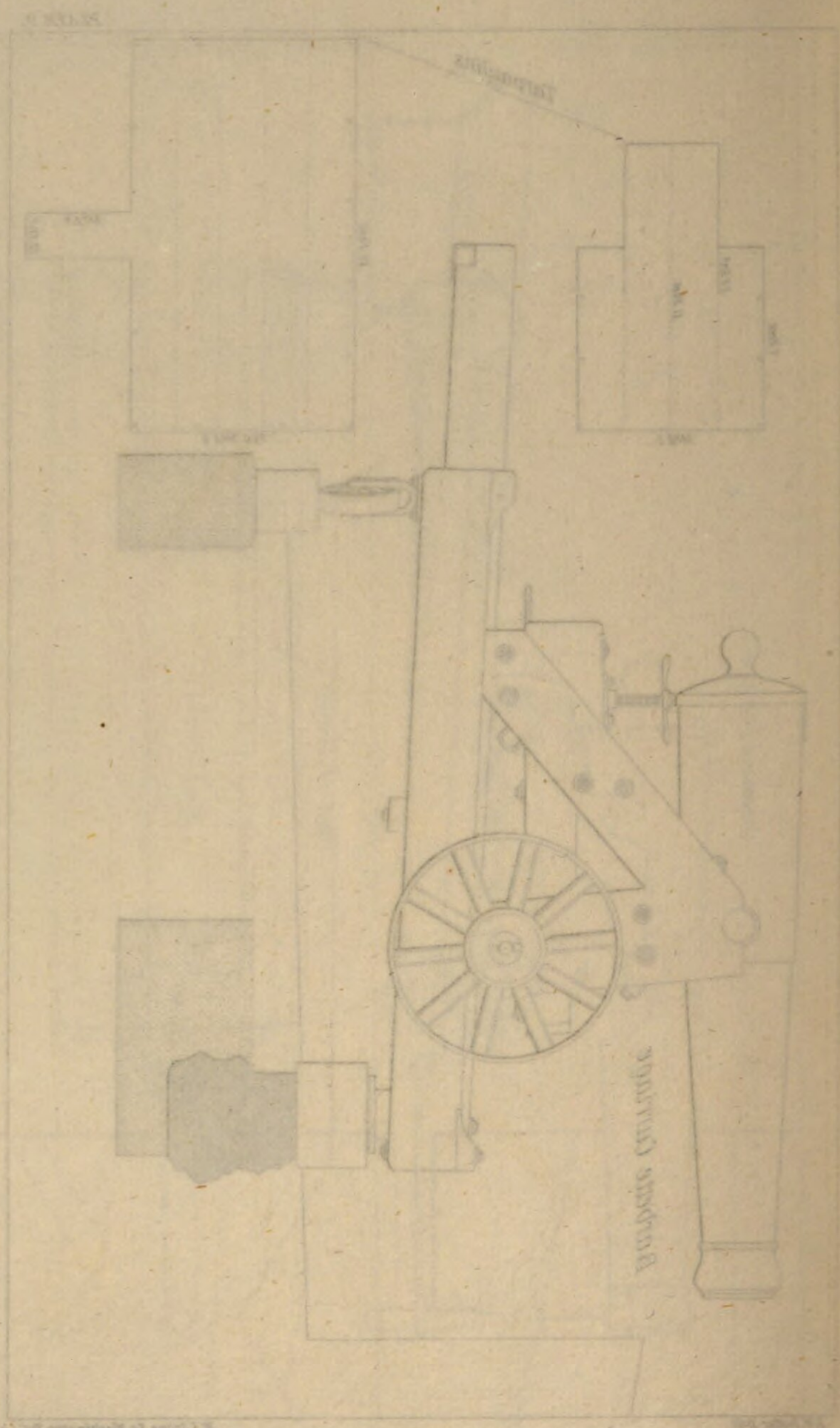


W.J. Stone Sc. Washington D.C.

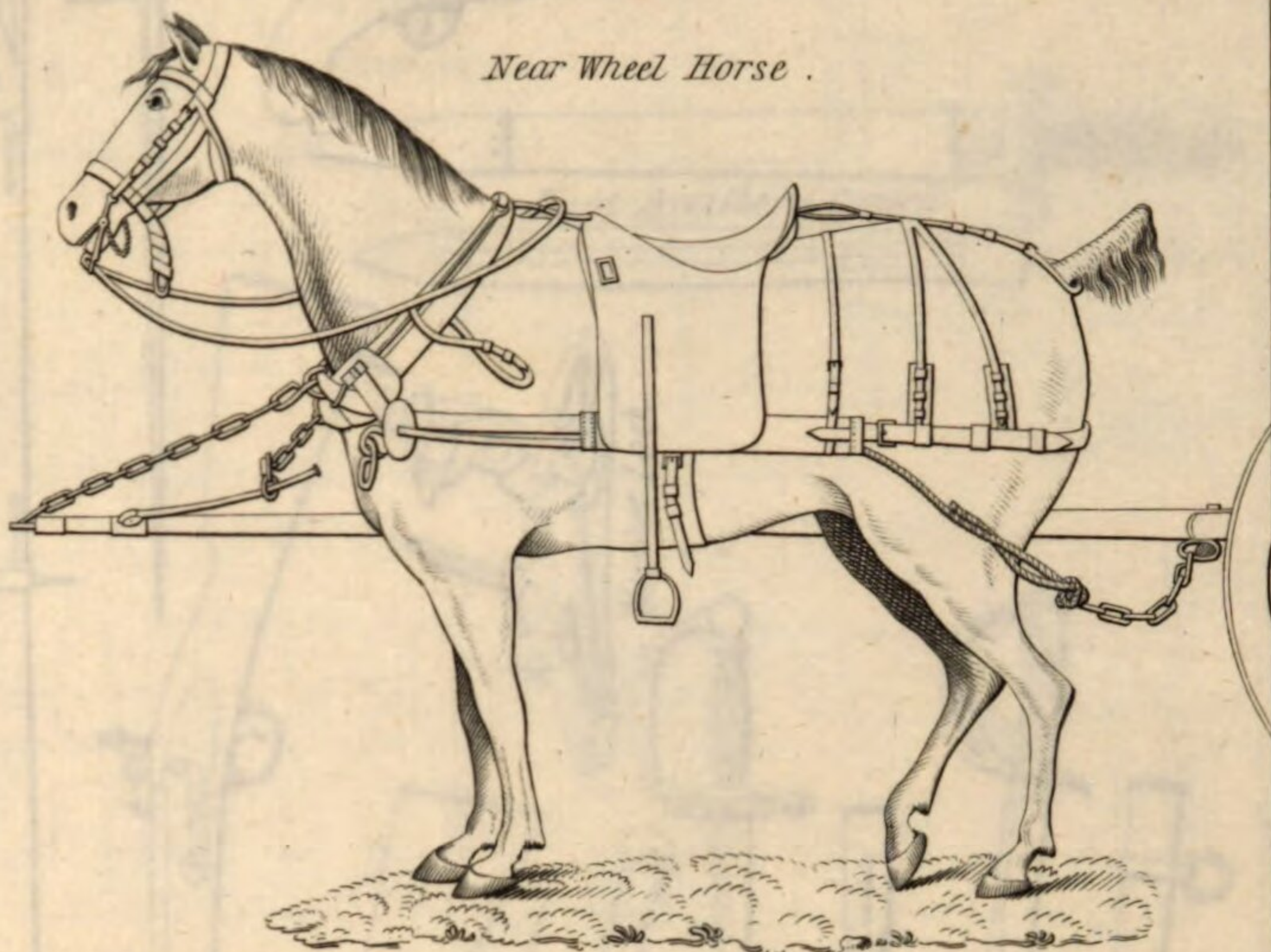


J.W. Butler Delt.

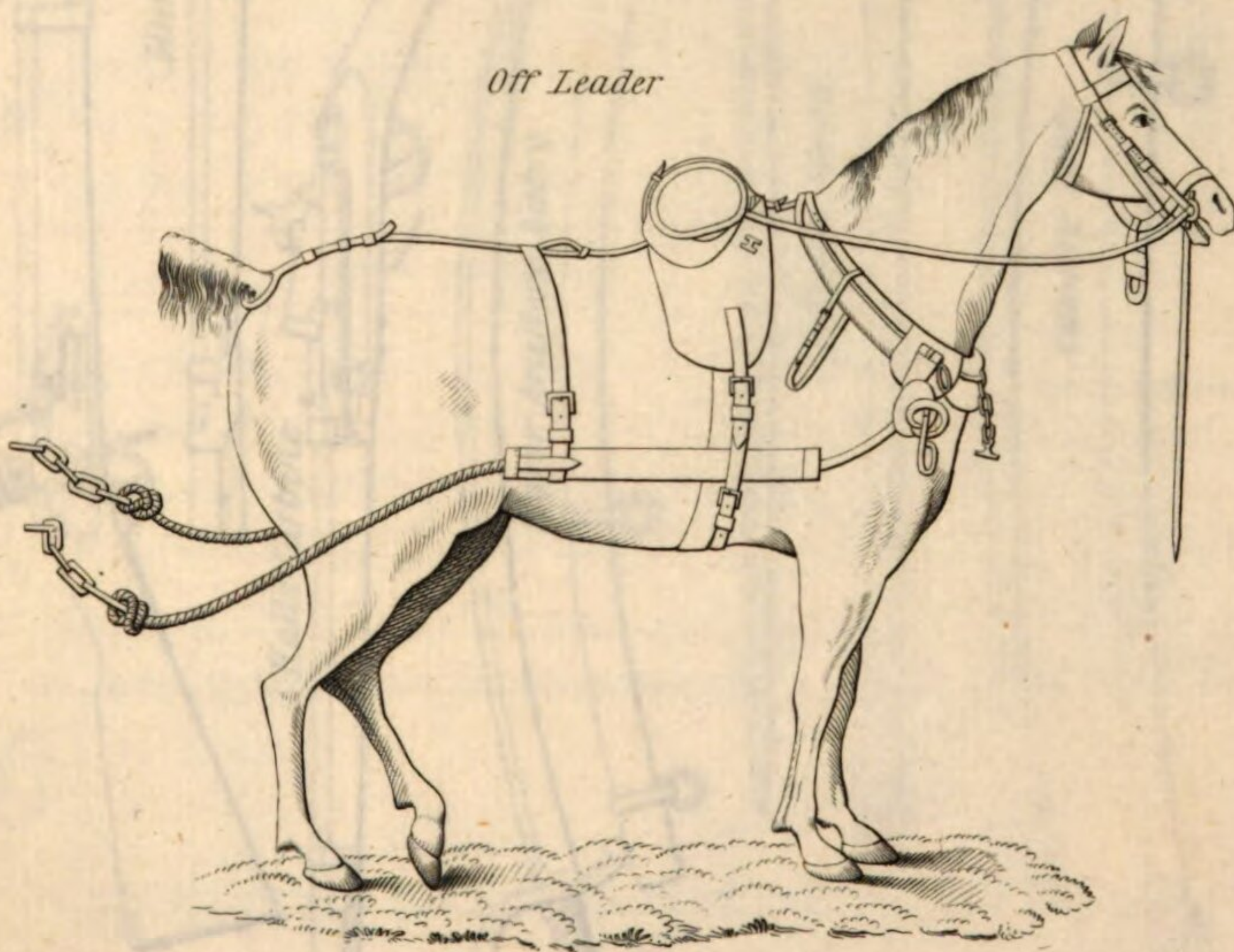
W.J. Stone Sc. Washington D.C.

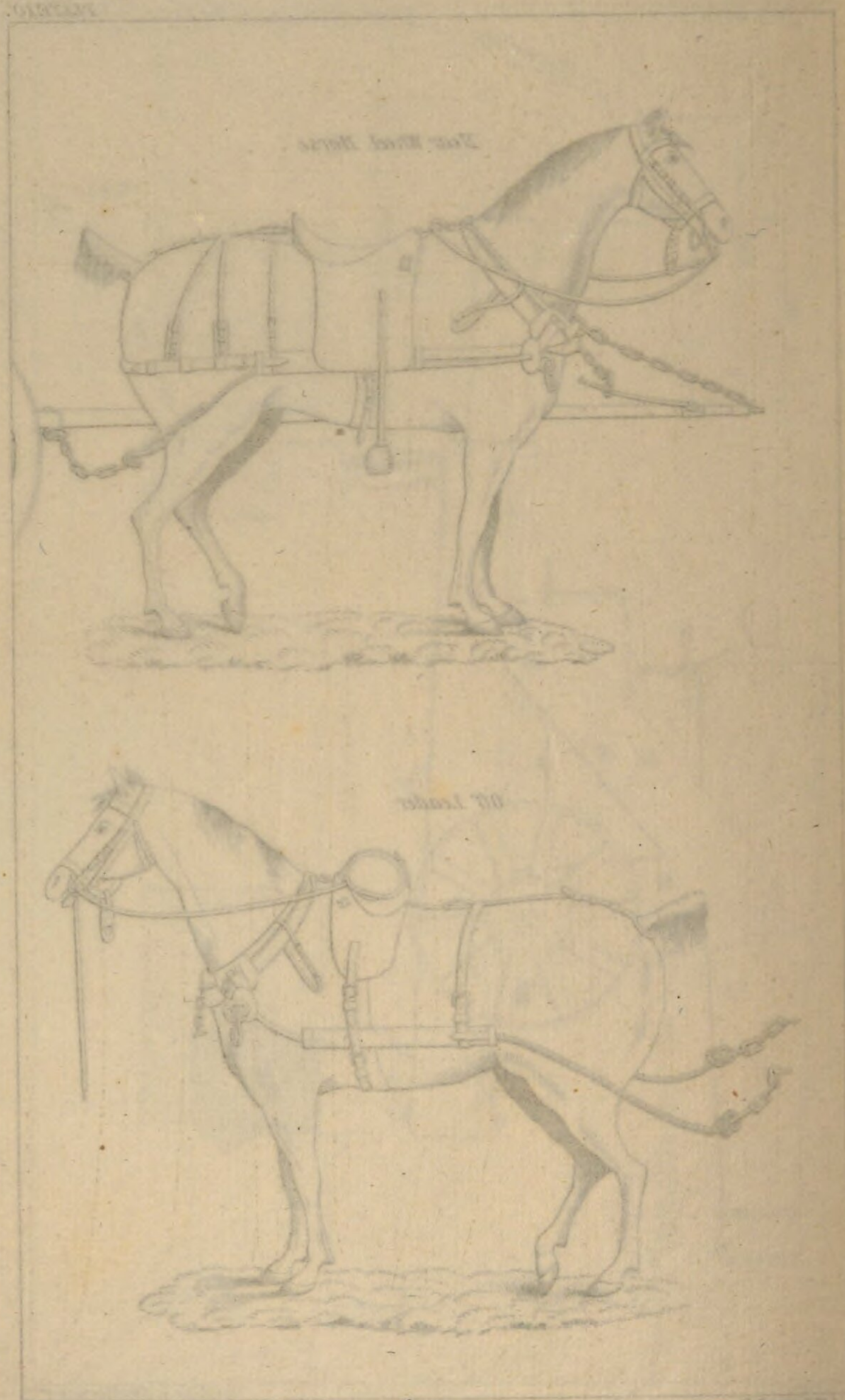


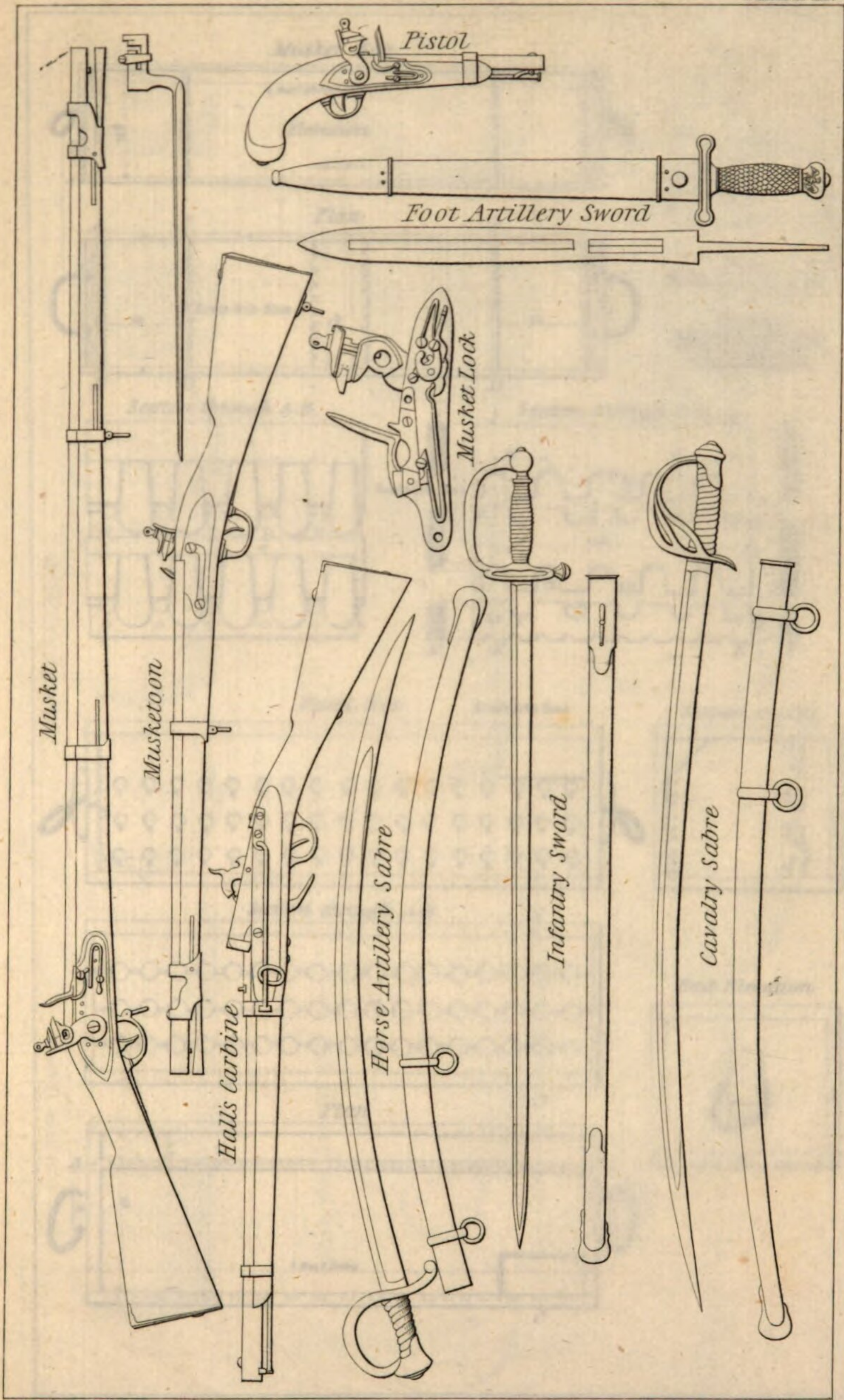
Near Wheel Horse .



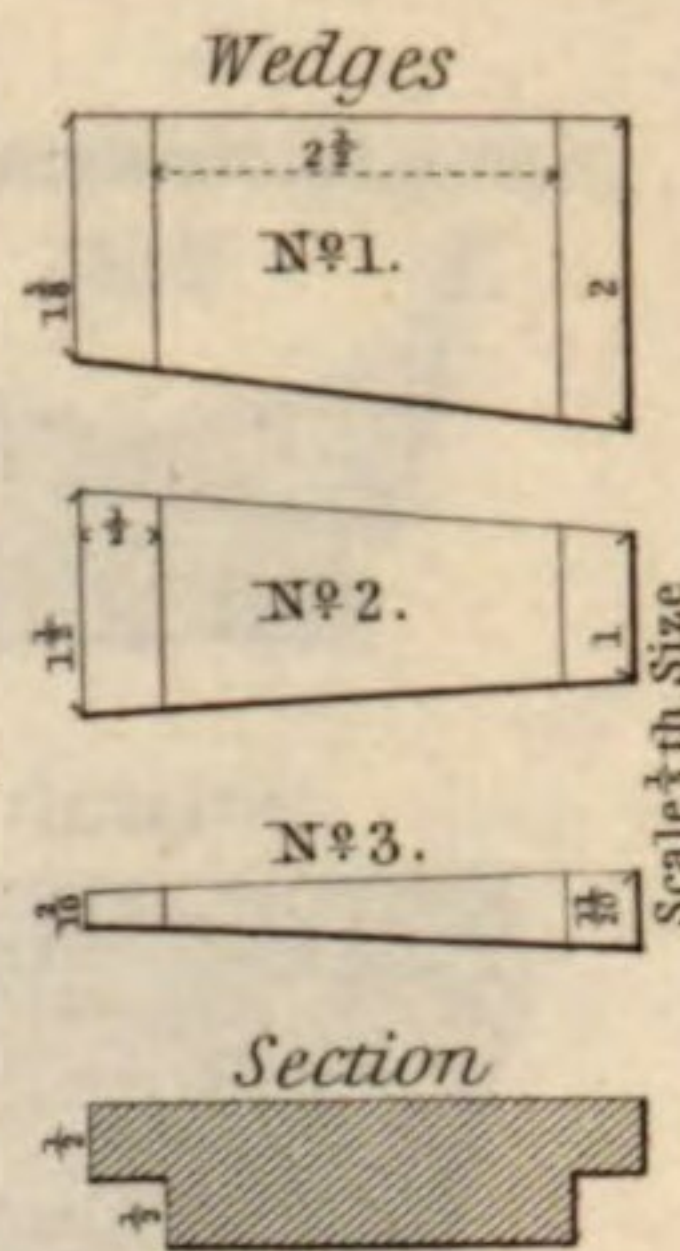
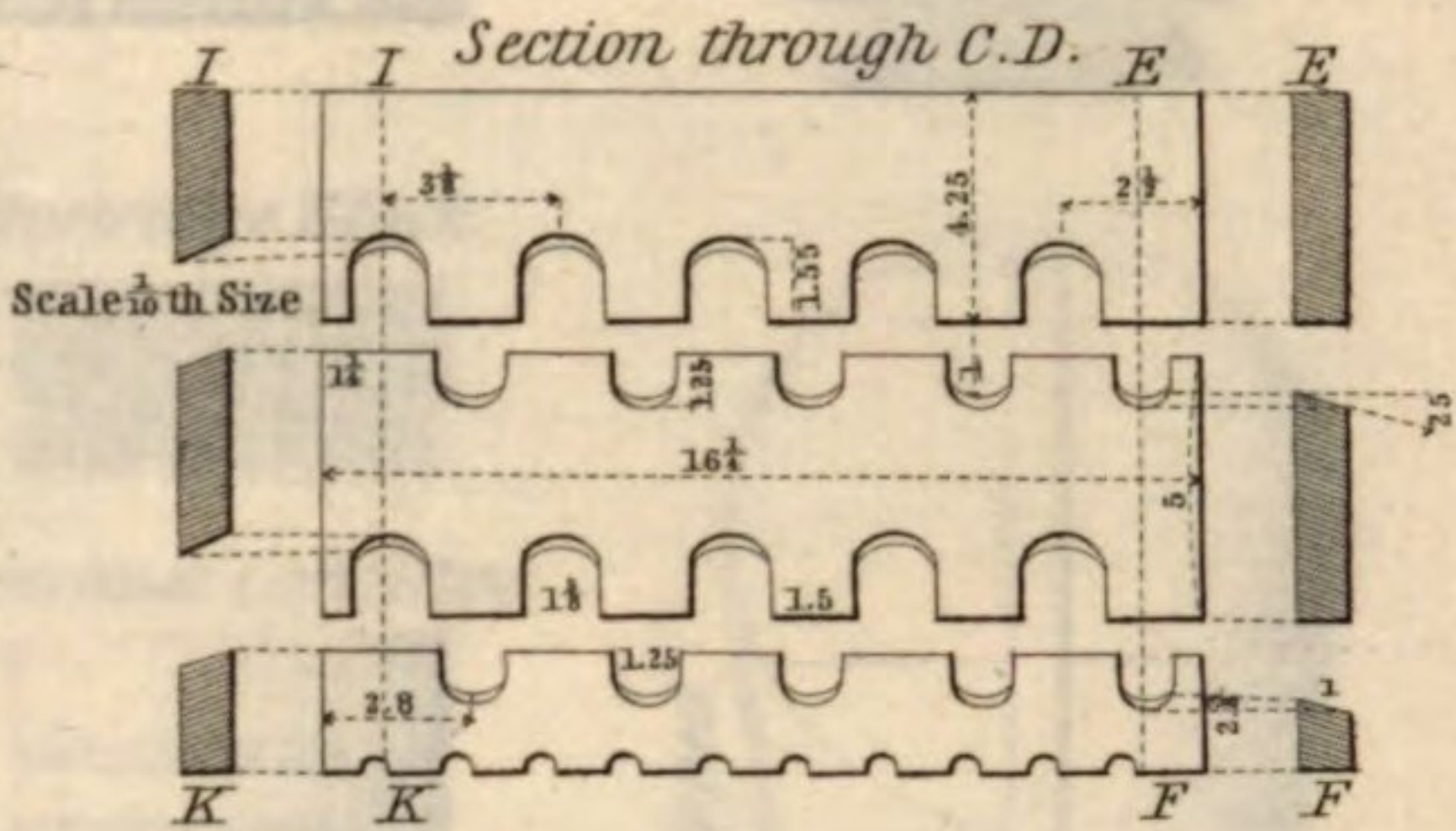
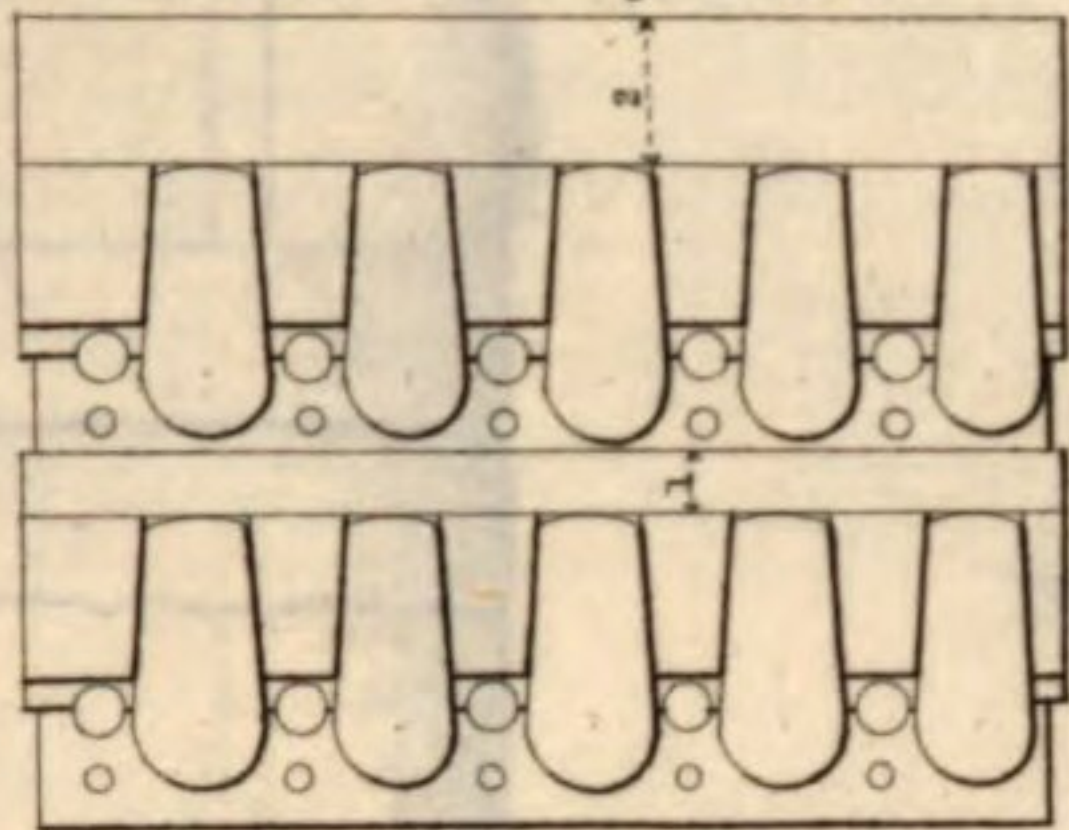
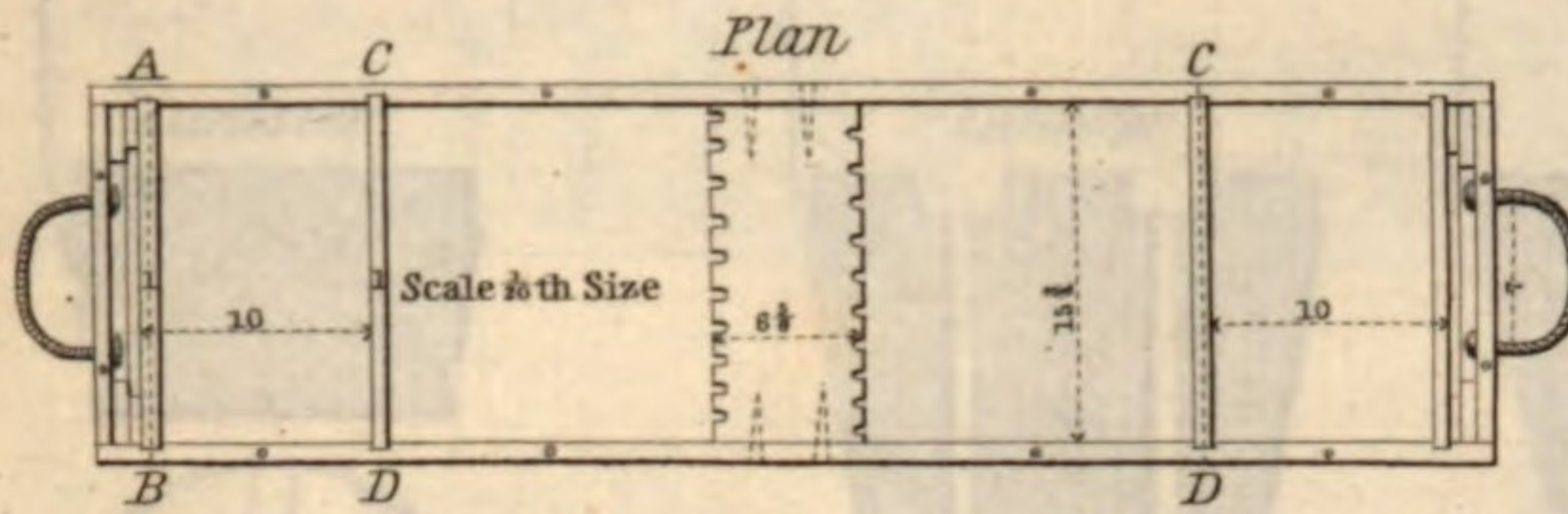
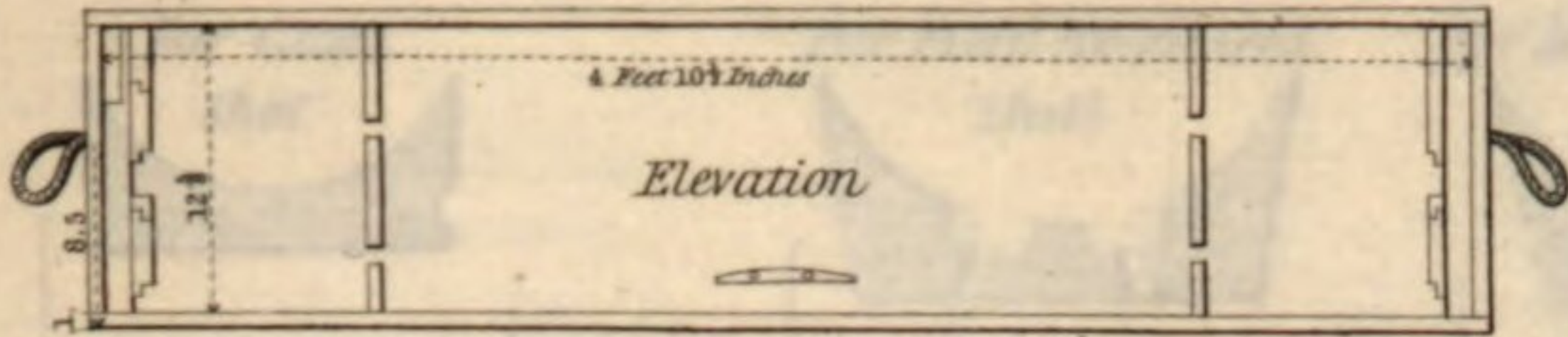
Off Leader





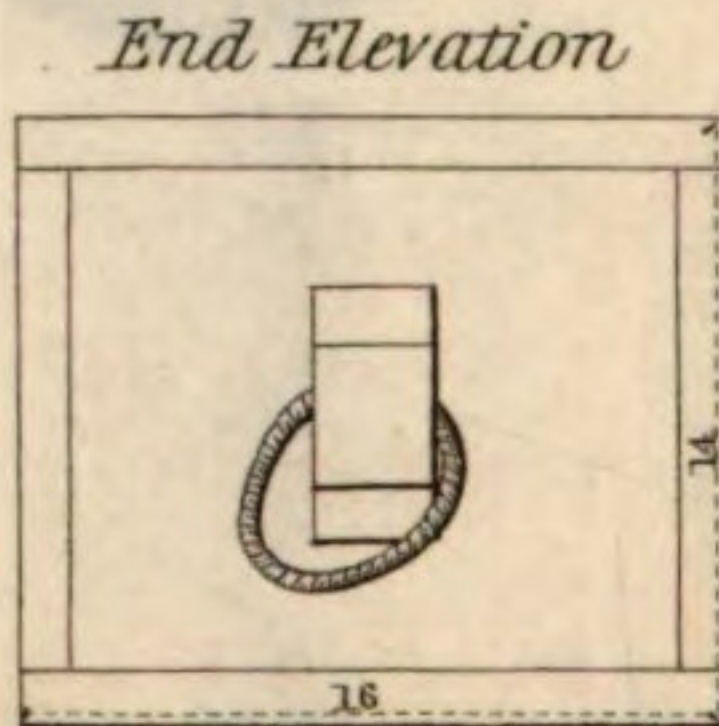
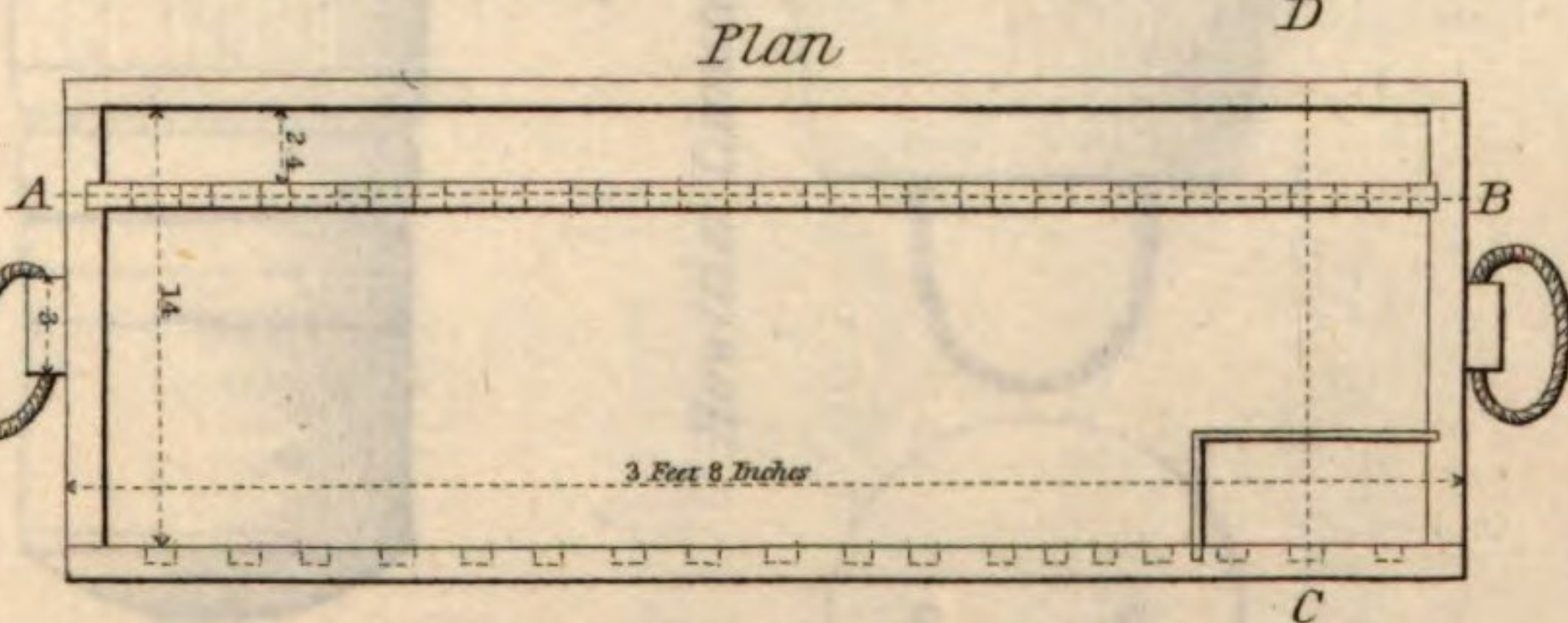
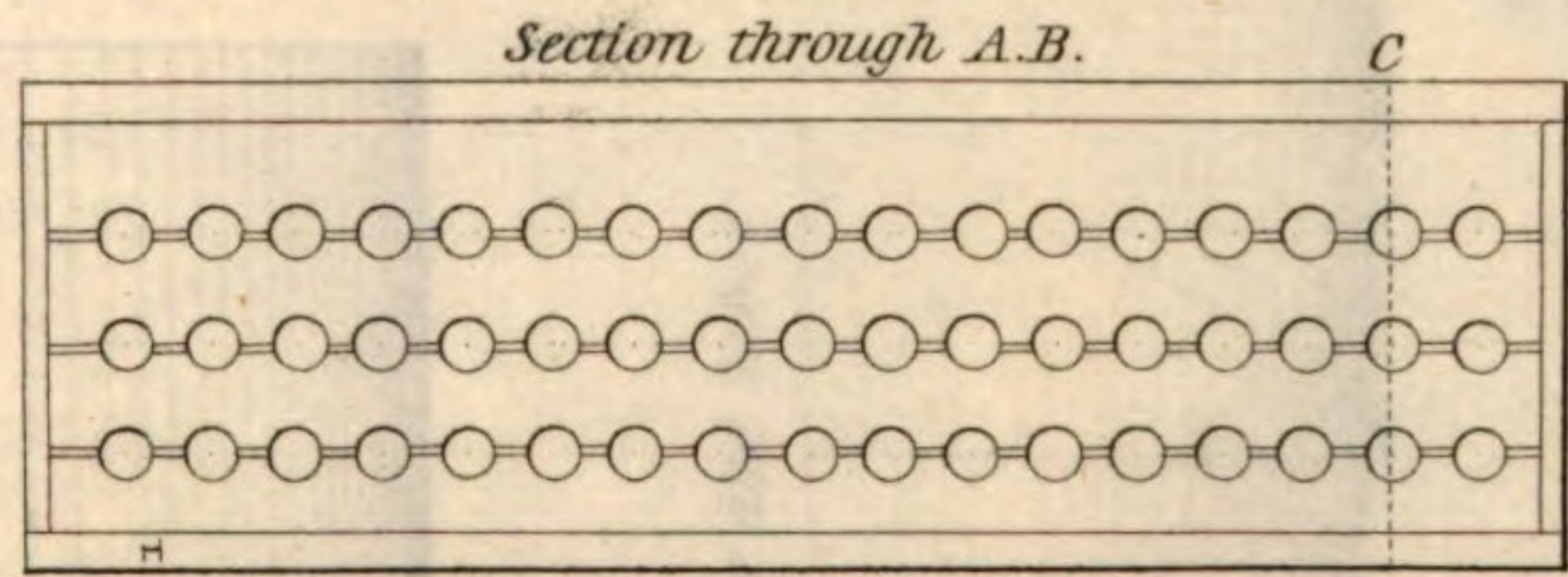
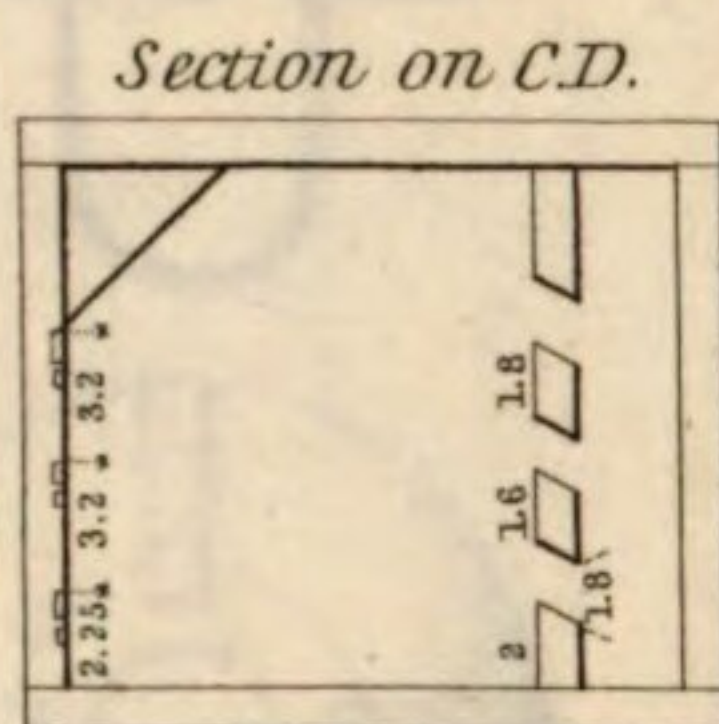
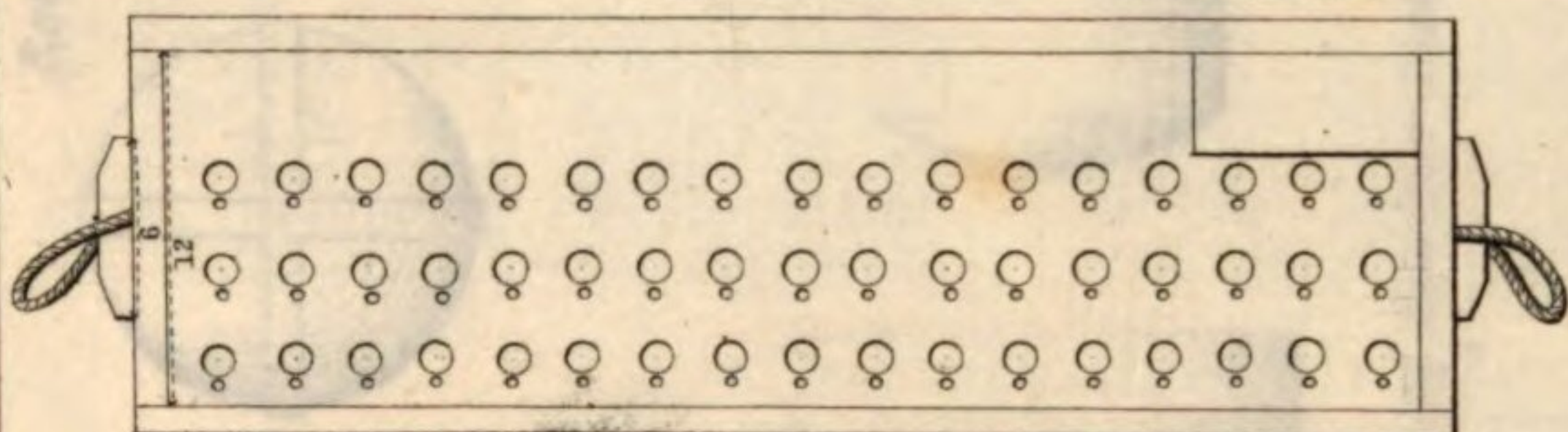


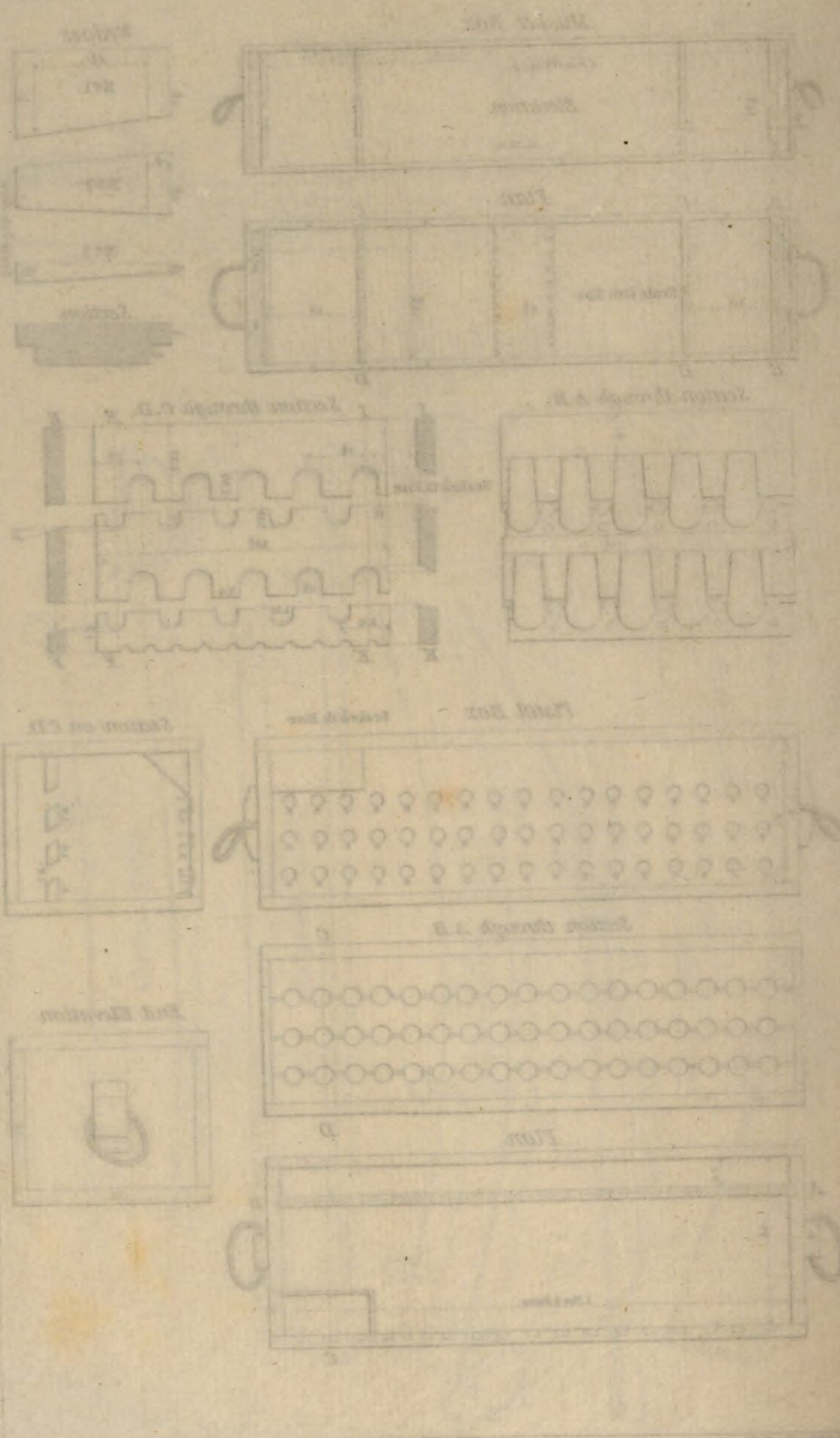
Musket Box

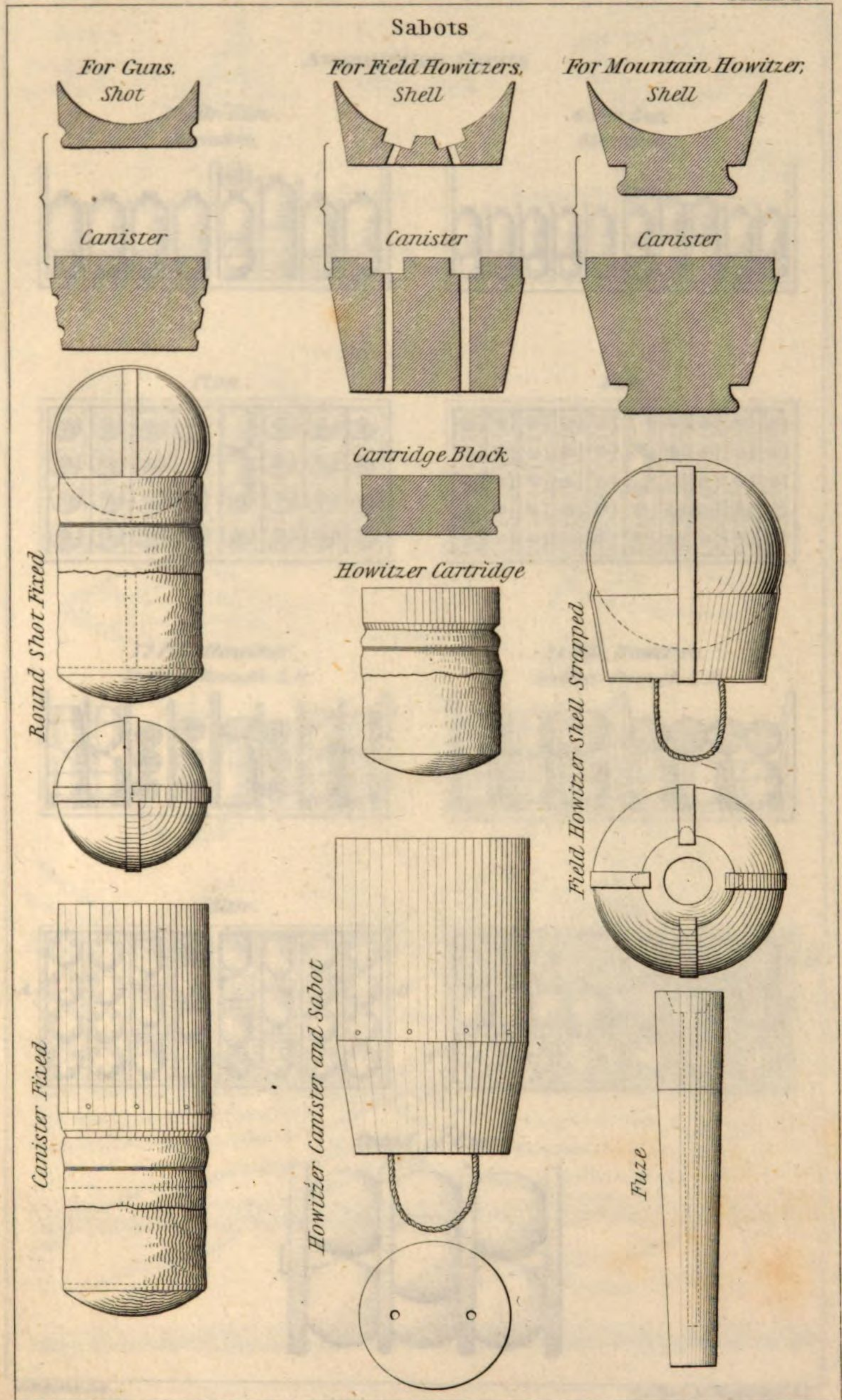


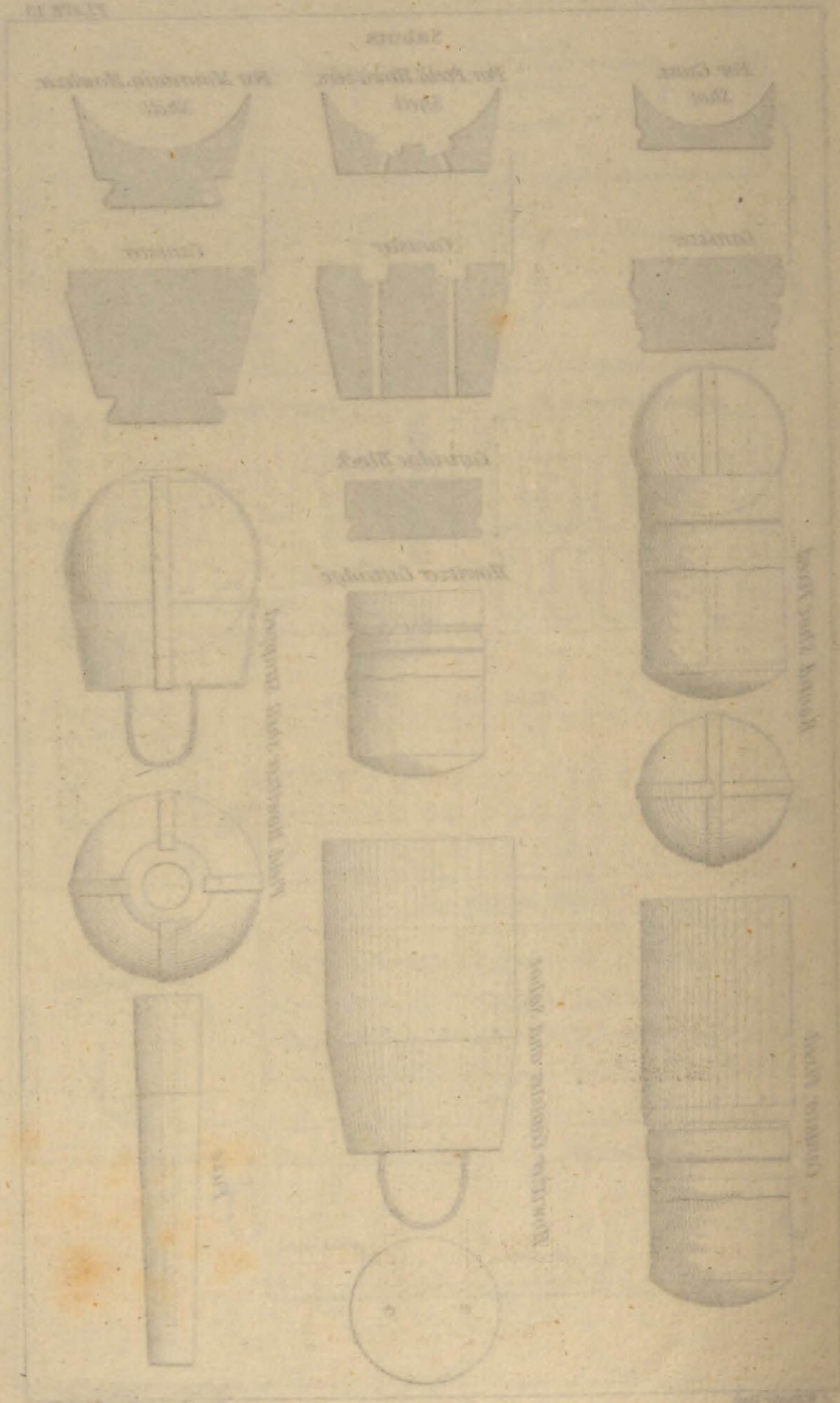
Pistol Box

Scale 1/10 th Size



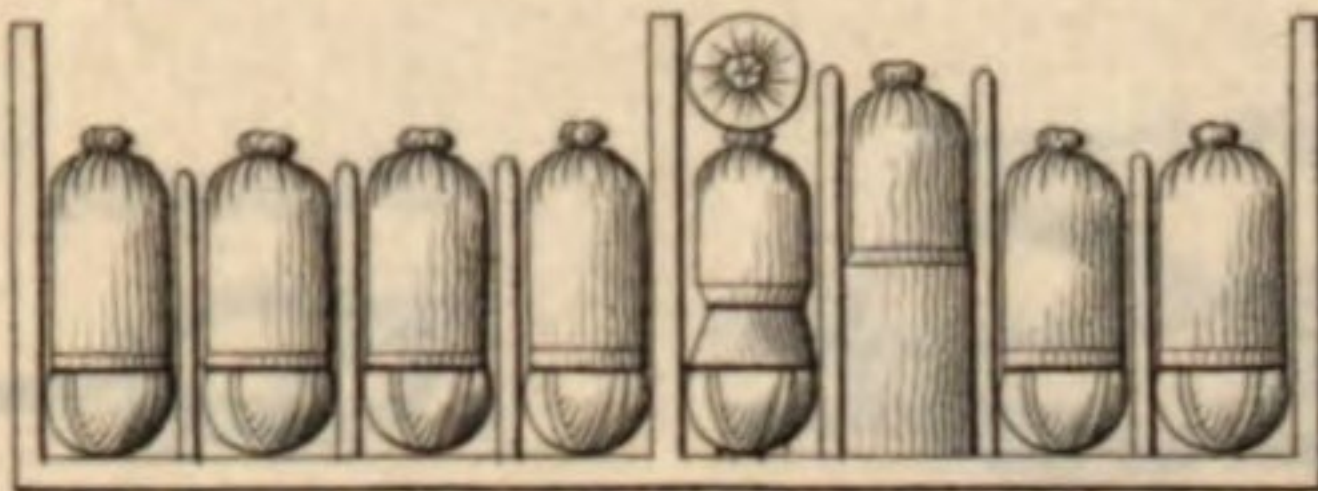




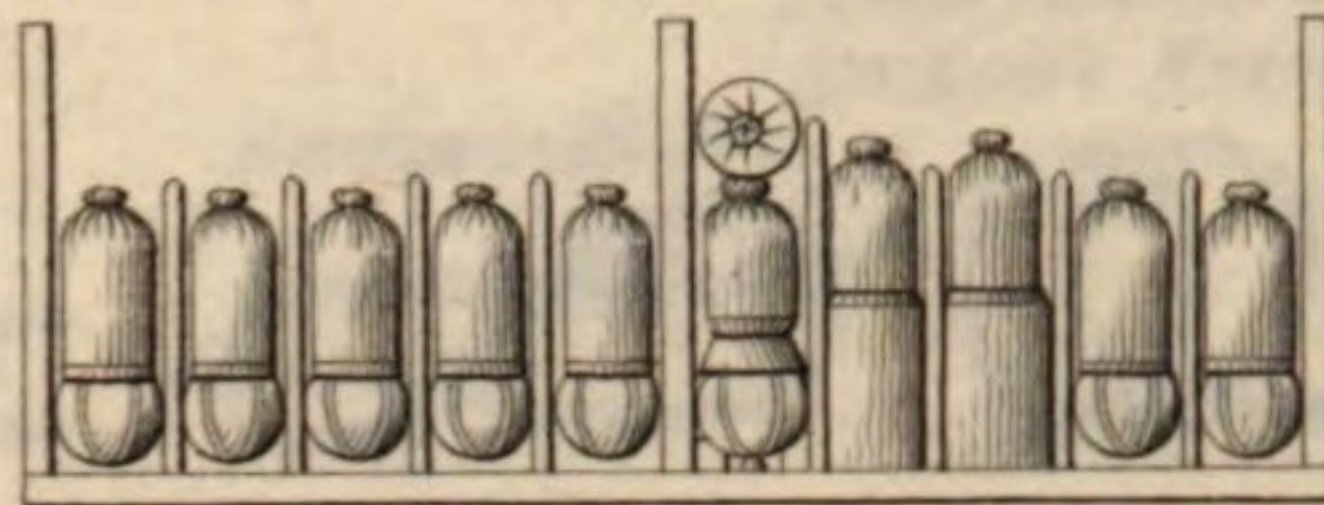


Ammunition Chests

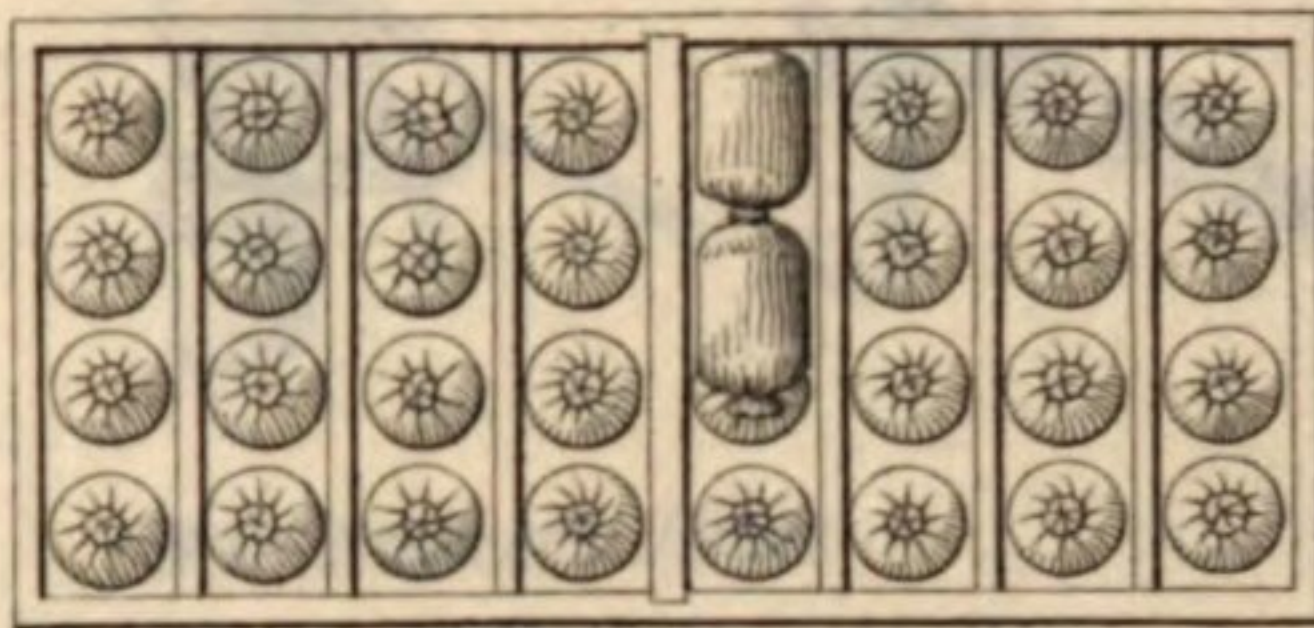
12 Pdr. Gun.
Elevation.



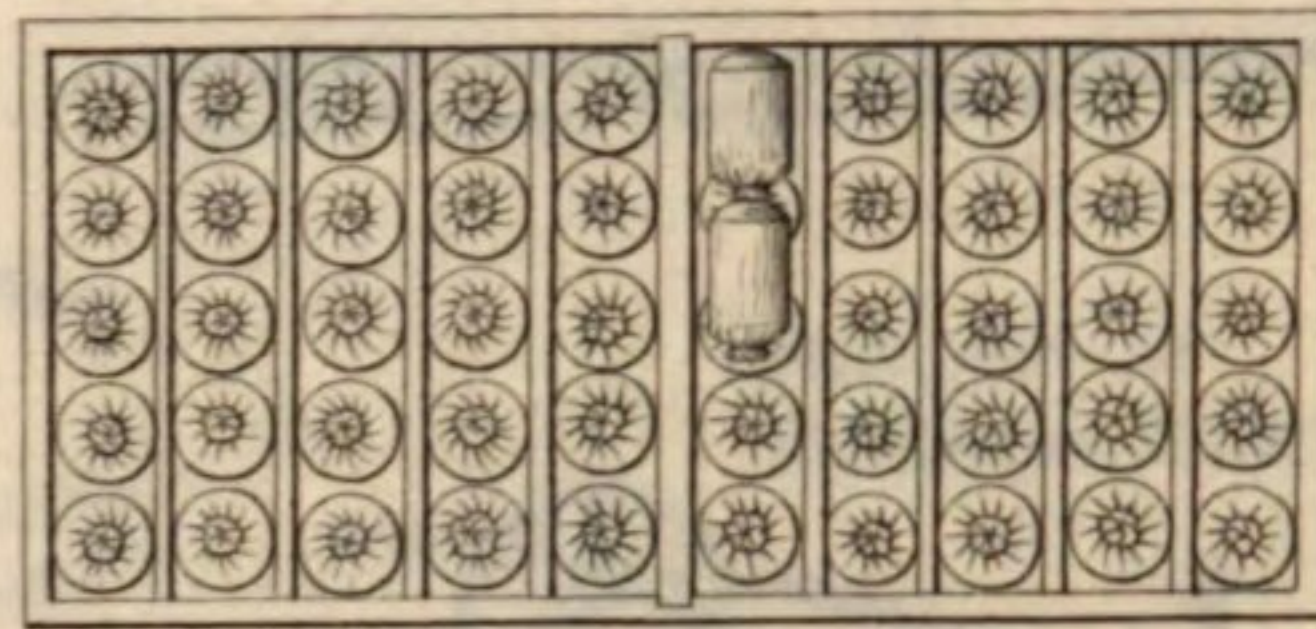
6 Pdr Gun.
Elevation.



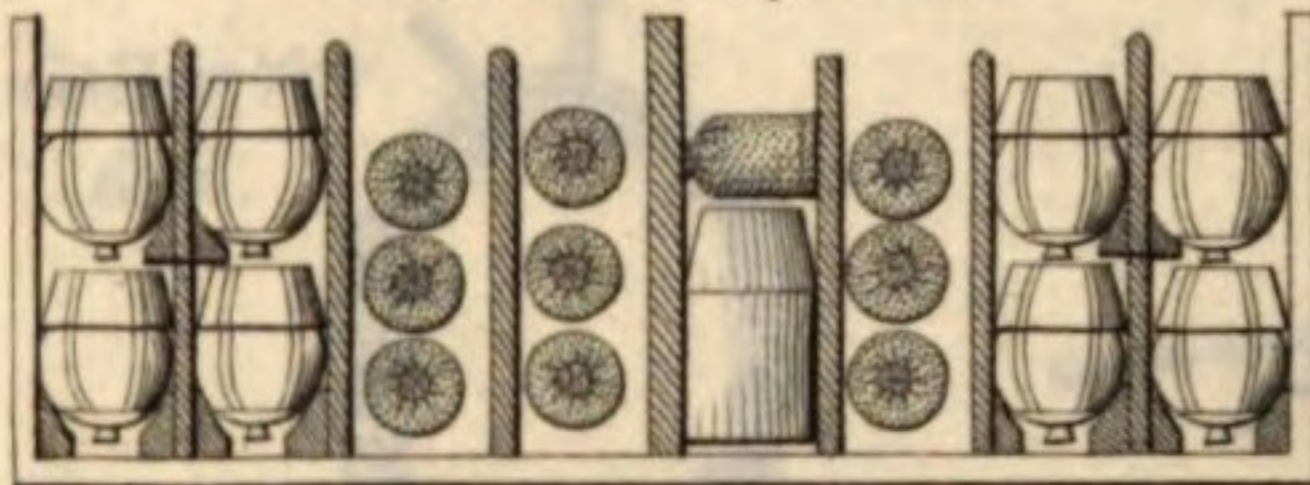
Plan.



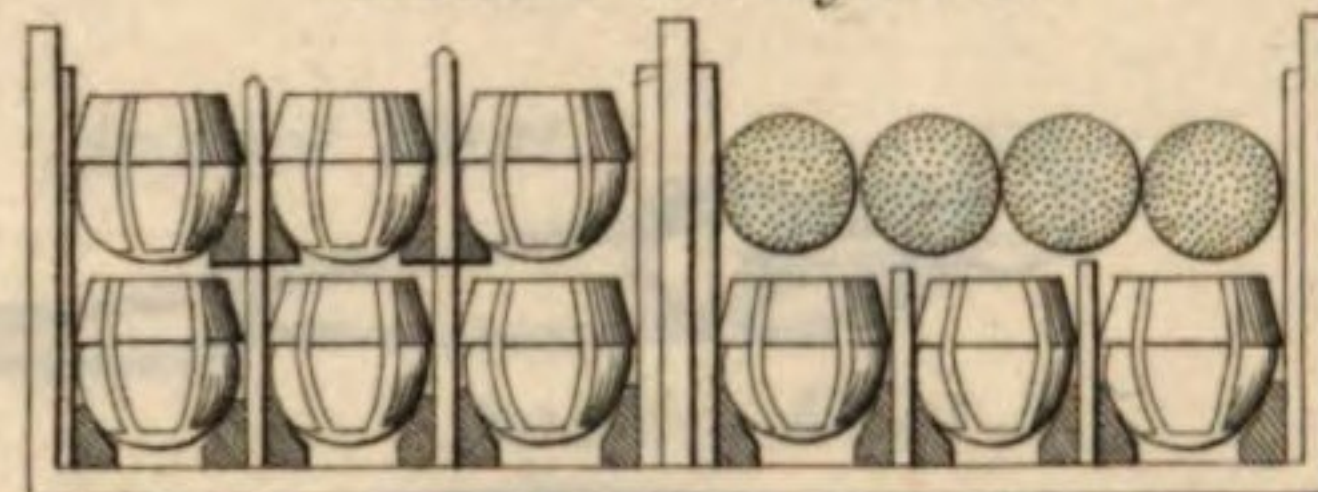
Plan.



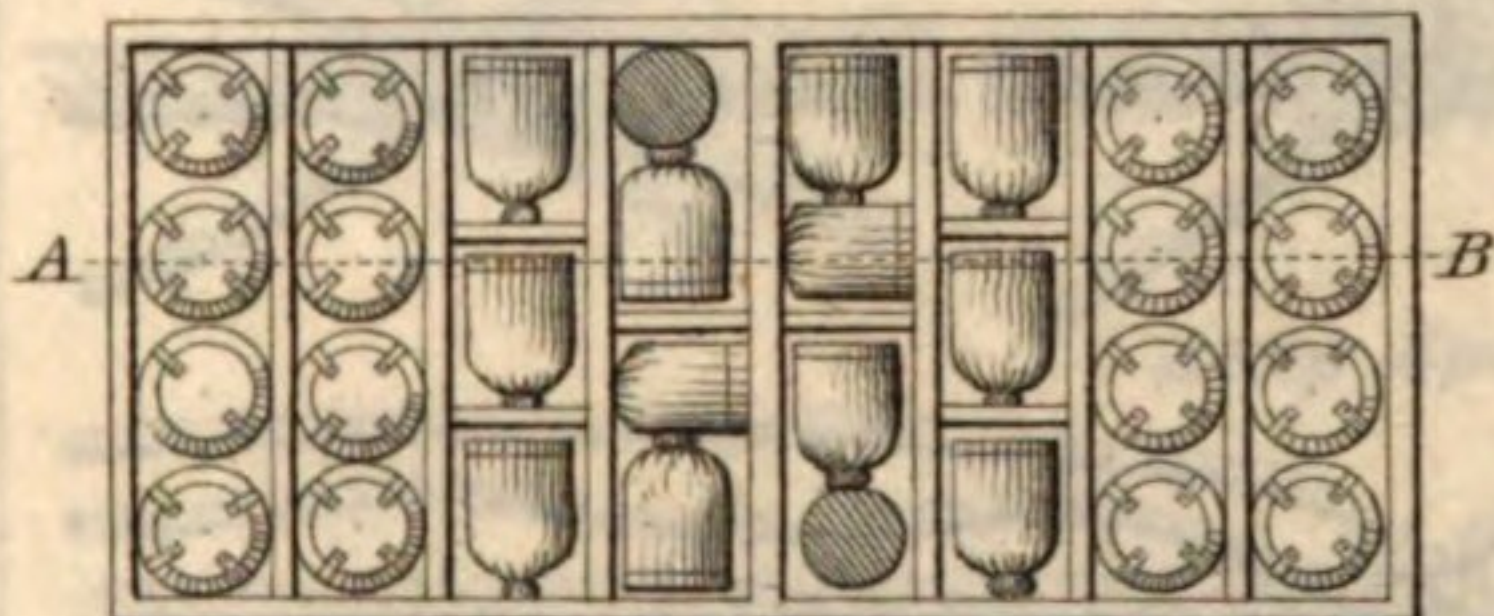
12 Pdr. Howitzer.
Section through A.B.



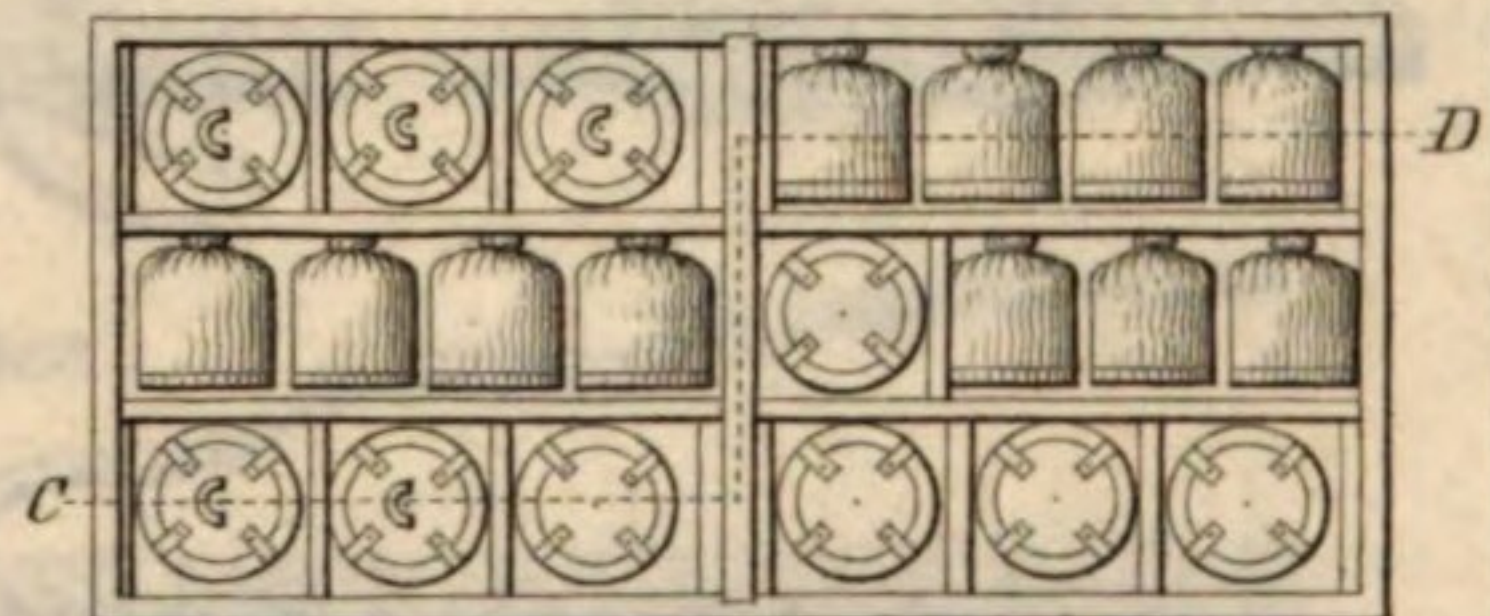
24 Pdr. Howitzer.
Section through C.D.



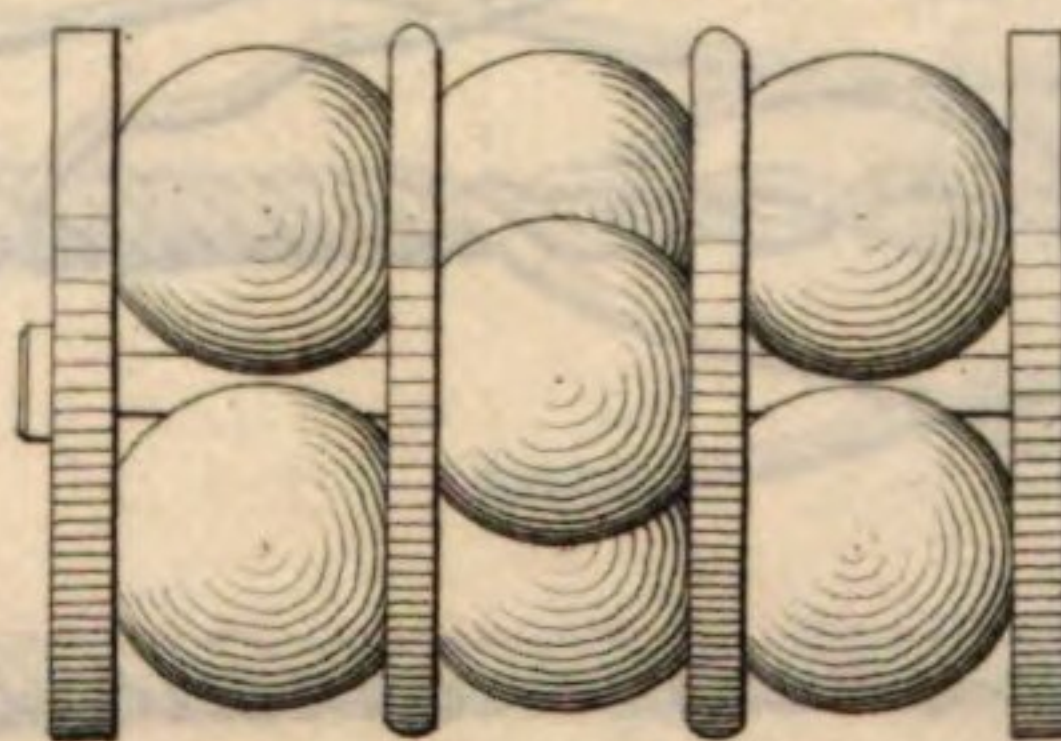
Plan.



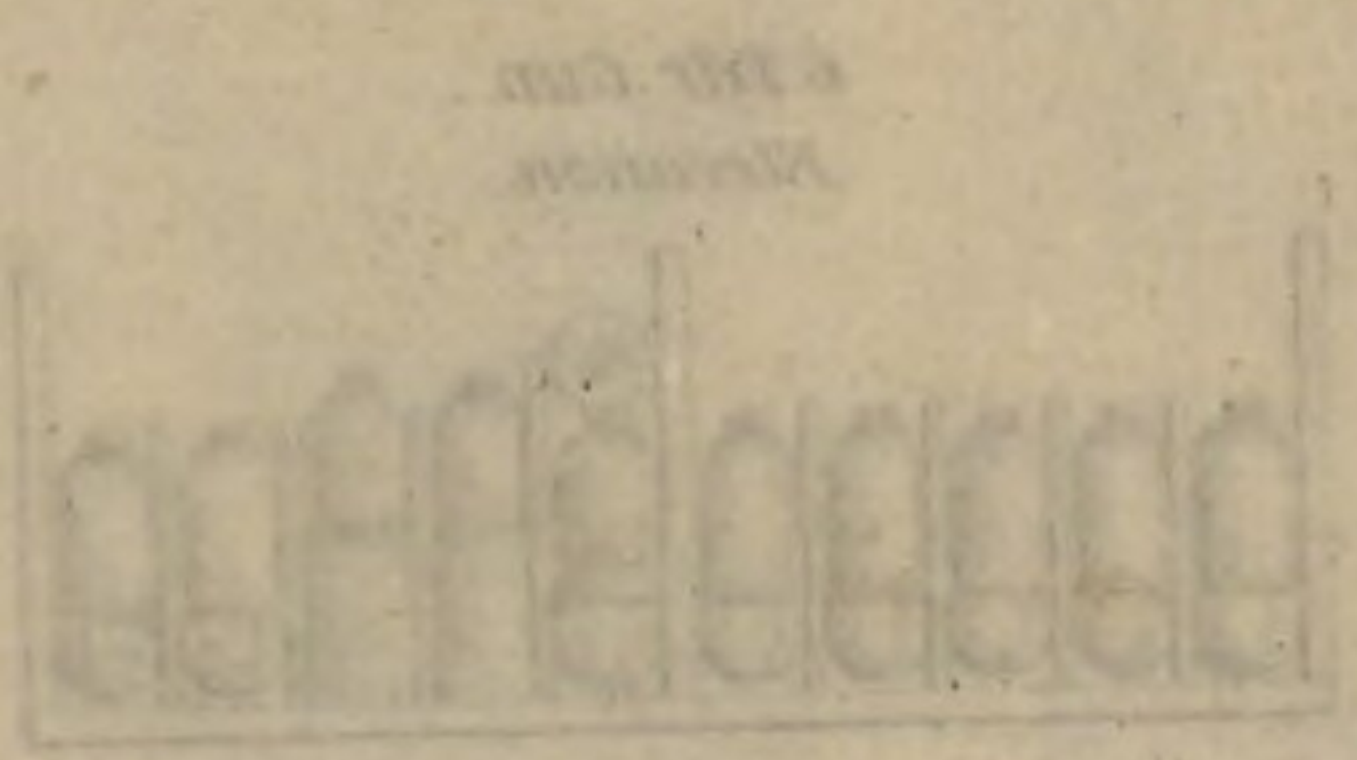
Plan.



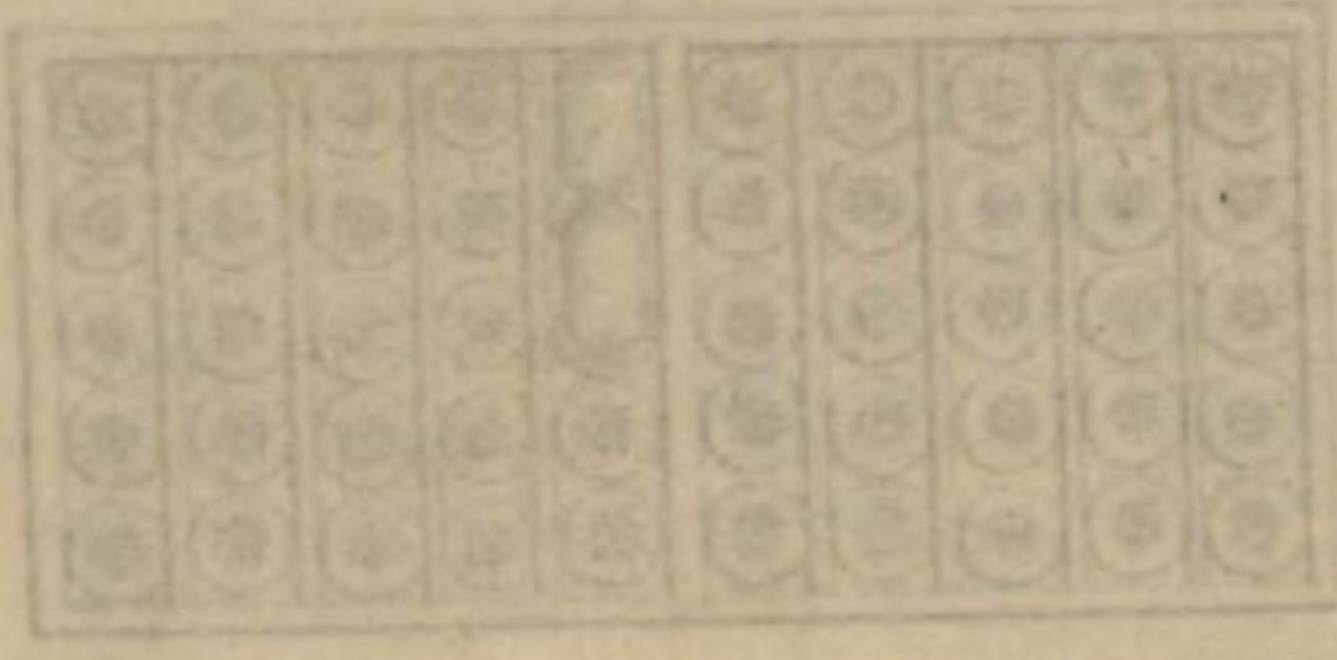
Stand of Grape.



SECTIONAL VIEW



PLAN



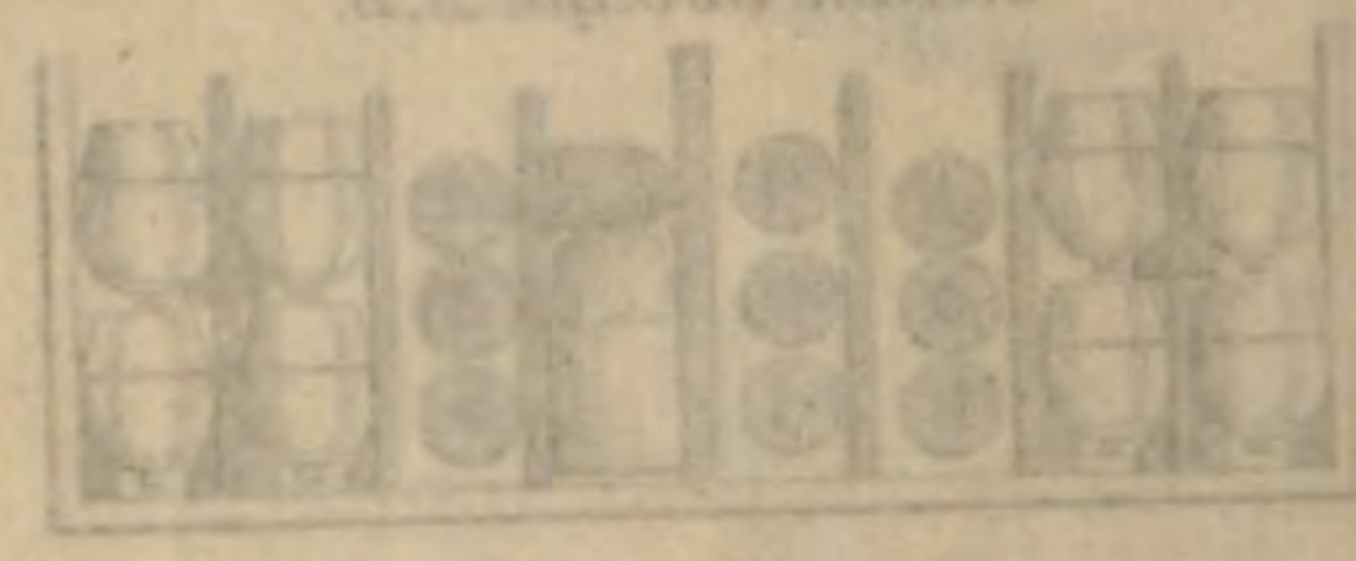
PLAN



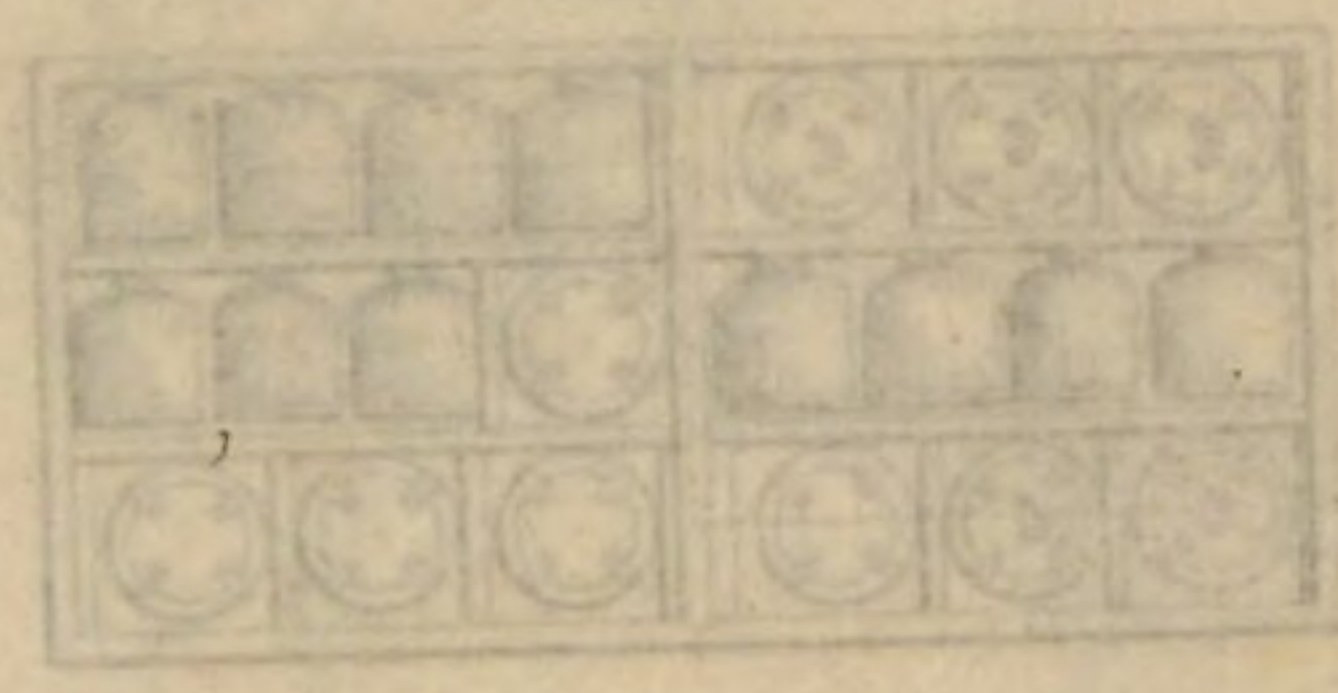
SECTION THROUGH A-B



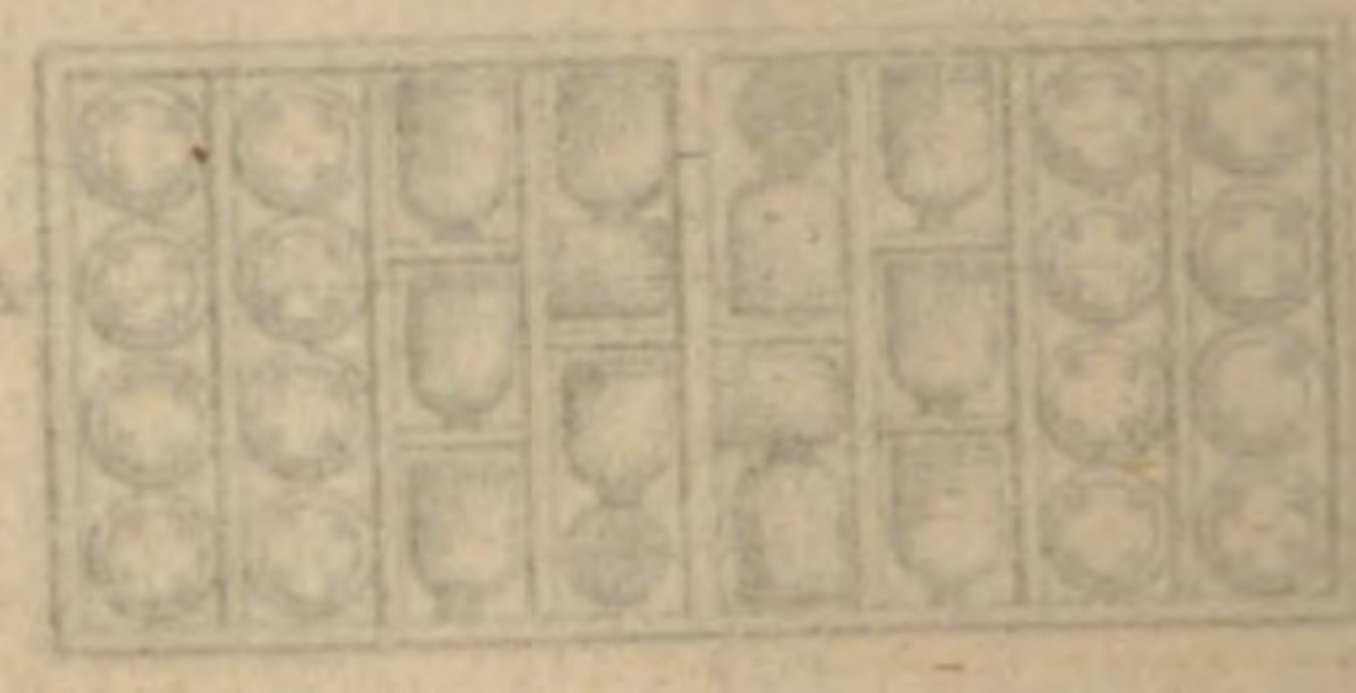
SECTION THROUGH A-B



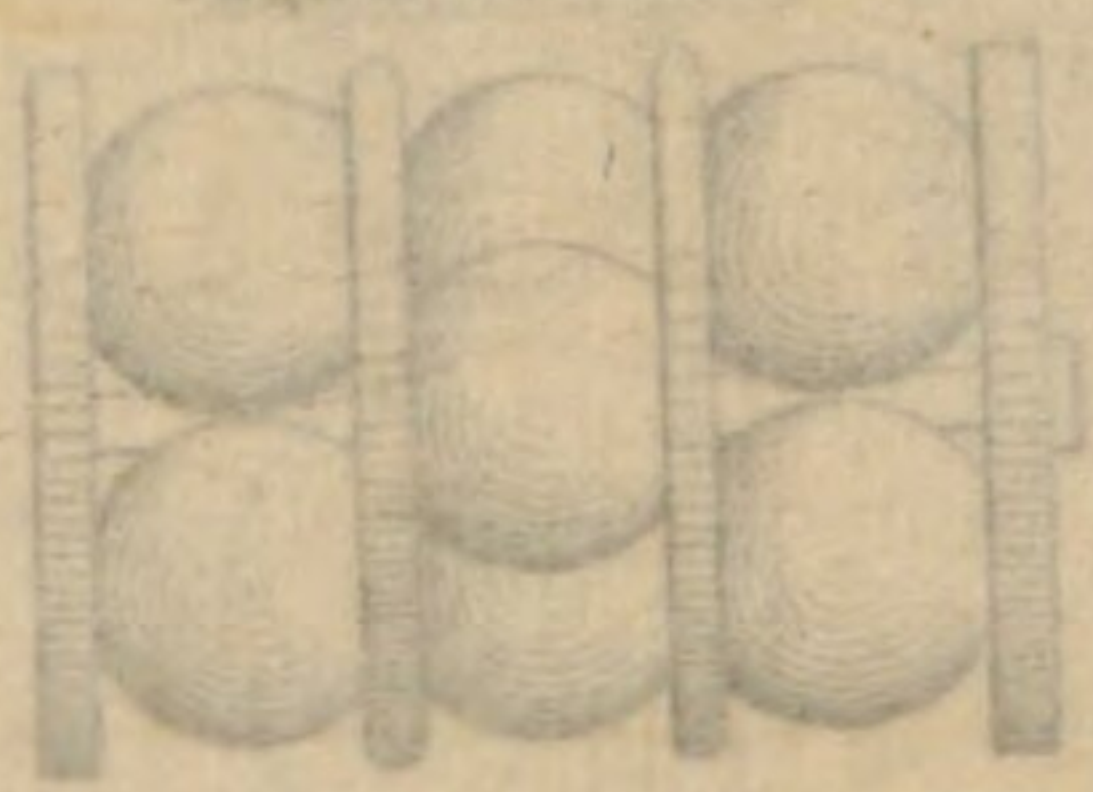
PLAN

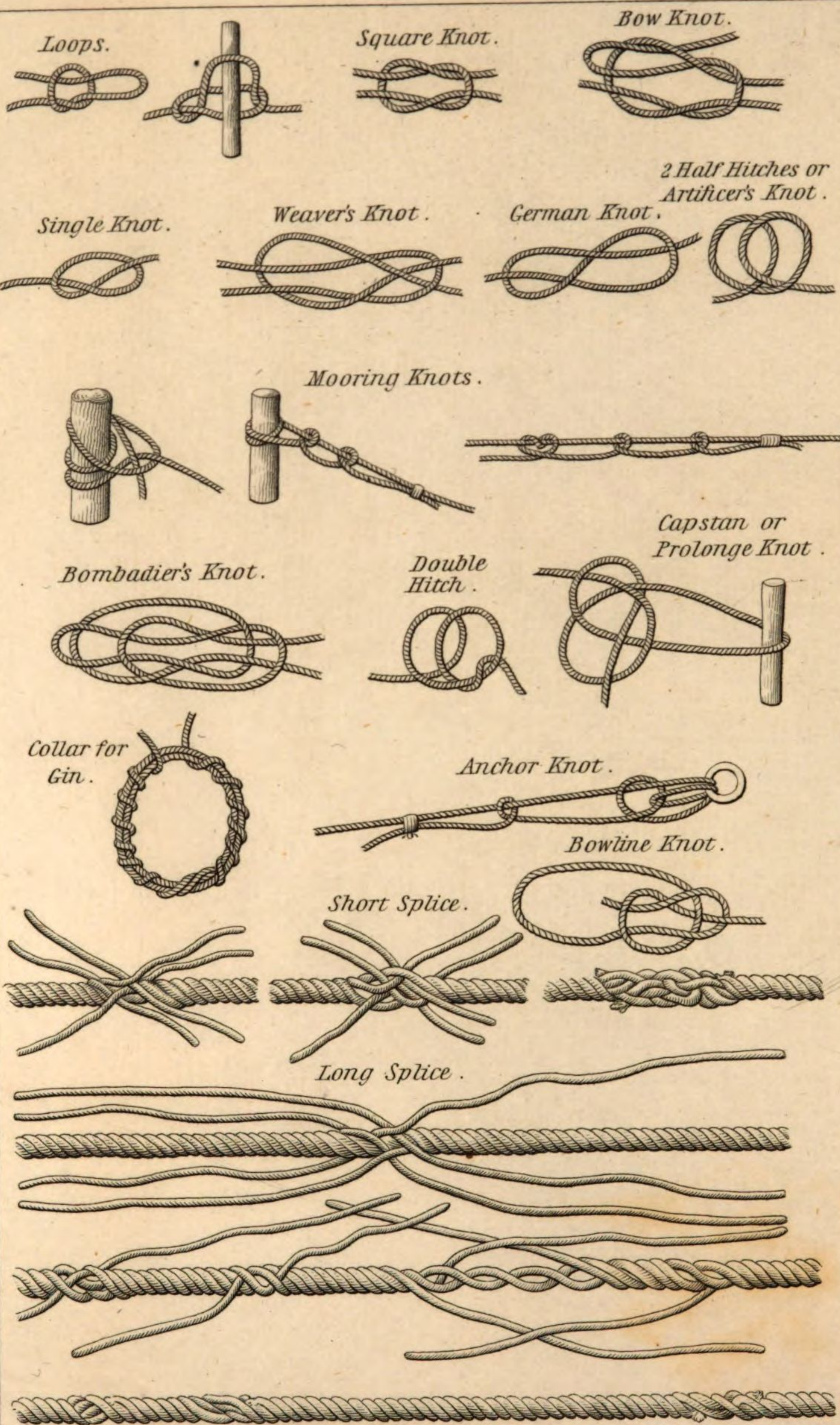


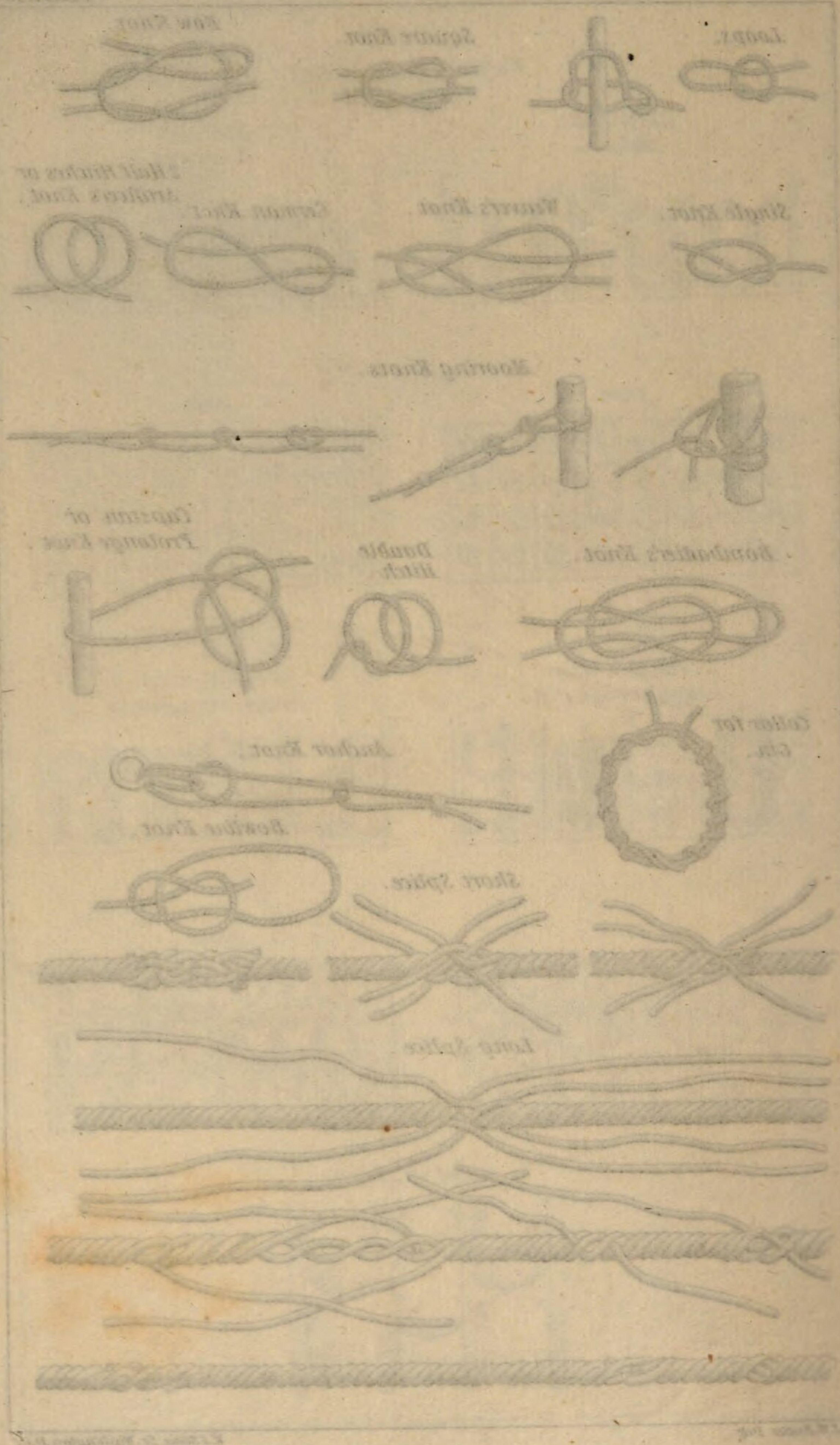
PLAN



STAND OF CUPS







Ordnance manual for the use of the officers of the united states army

Washington 1841

Sc.mil. 80 u

urn:nbn:de:bvb:12-bsb10784686-6